TETRA TECH NUS, INC.
661 Andersen Drive ▪ Pittsburgh, Pennsylvania 15220-2745
(412) 921-7090 ▪ FAX (412) 921-4040 ▪ www.tetratech.com
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Tetra Tech NUS Project No. 7606

Mr. Lonnie Monaco
Naval Facilities Engineering Command
Northern Division
Environmental Contracts Branch, Mail Stop #82
10 Industrial Highway
Lester, Pennsylvania 19113

Reference: CLEAN Contract No. N642472-90-D-1298
Contract Task Order No. 291

Subject: Casey Village/Shenandoah Woods Area Groundwater Investigation Results

Dear Lonnie:

As per your request, attached is a summary of the Navy and USGS/EPA investigation results relative to the trichloroethene contamination found in groundwater in the Casey Village and Shenandoah Woods housing areas. Also included are investigation results for carbon tetrachloride detected in groundwater in the subject area.

Please contact me if you have any questions in regards to this submittal, or would like to discuss the issue further.

Sincerely,

Jeffrey P. Orient, P.G.
Senior Hydrogeologist

cc. M. Fohner
G. Glenn
N. Teamerson
K. Davies
D. Ostrauskas
R. Sloto
A. Flipse
J. Burke
A. Winkler
D. Fennimore
T. Sauder
File 7606

CASEY VILLAGE/SHENANDOAH WOODS GROUNDWATER EVALUATION

Introduction

In late 1993, as part of the Navy's investigation of Area B groundwater, groundwater samples were collected from private residential wells in the Casey Village housing development located immediately east of NAWC and, in particular, east of/adjacent to the NAWC Shenandoah Woods enlisted persons housing area. This sampling detected trichloroethene (TCE) and tetrachloroethene (PCE) at levels which presented a threat to human health. Carbon tetrachloride was also detected in several residential wells. Based on the information available at the time, the EPA determined that the PCE contamination apparently was attributable to non-NAWC related sources. The sources of the TCE contamination and carbon tetrachloride were unknown at the time. In response, the Navy and EPA connected residents whose wells were impacted to public water supplies. Summarized below are the results of the follow-up Navy and EPA investigations of the TCE contamination and carbon tetrachloride detections of interest. Since early phases of these investigations found that neither the TCE nor the carbon tetrachloride were attributable to Area B, the subject groundwater is not considered part of Area B groundwater (see final ROD of 9/6/00 for details regarding Area B groundwater).

Carbon Tetrachloride Issue

C ntaminant Distribution

Concentrations of carbon tetrachloride at levels slightly above the MCL of 5 ug/L have historically been found in two wells within the Casey Village housing development and two monitoring wells in the adjacent, Navy-owned, Shenandoah Woods housing area. The detections within Casey Village include two adjacent residences on Rambler Road. During the 1993-1994 time period, each residence was sampled twice, with carbon tetrachloride detections ranging from a low of 6 ug/L to a high of 8.7 ug/L. Shortly after the 1994 samples were collected, the wells were abandoned as part of the removal action taken by the Navy and EPA to connect Casey Village residences to public water. As a result, no additional samples have been collected since then. Table 1 presents a summary of residential well sampling performed by the Navy in the Casey Village area during 1993 and 1994.

The detections of carbon tetrachloride within the Shenandoah Woods housing area are located along the boundary between the Shenandoah Wood housing area and Casey Village, extending to the southern portion of the Shenandoah Woods development. Two Navy shallow monitoring wells in this area, HN-9S and HN-62S, have had consistent detections of carbon tetrachloride ranging from a low of 6.5 ug/L to a high of 13 ug/L over six rounds of sampling covering a time span from 1994 to 2000. Table 2 summarizes the sampling results for the Navy's monitoring wells located in the Shenandoah Woods area.

In addition to these two areas of elevated carbon tetrachloride detections, an isolated carbon tetrachloride detection at the MCL of 5 ug/L was found in a single residence located along Davisville Road, approximately 1,200 feet south of the other detections of carbon tetrachloride. This isolated detection appears to have no relationship to the Shenandoah Woods and Casey Village carbon tetrachloride detections.

As shown on Figure 1, the wells with carbon tetrachloride detections fall along an east-west line extending from the Rambler Road residences to HN-5S/D. A pumping test performed by the USGS in a Casey Village residential well during a 1995-1996 groundwater investigation (Sloto,

et.al., 1998) identified preferential drawdowns along east-southeast to west-northwest and east-west linear trends, indicating enhanced hydraulic communication within the bedrock aquifer along these trends.

Groundwater Flow Patterns

Based on historic groundwater level data, the highest groundwater elevation among the wells with carbon tetrachloride levels above the MCL is in monitoring well HN-9S, located along the boundary between Shenandoah Woods and Casey Village. Monitoring well HN-62S typically has a groundwater elevation approximately 1 foot lower than HN-9S, indicating that the carbon tetrachloride in these wells is not migrating from the base interior towards the Casey Village-Shenandoah Woods boundary. In addition, historic groundwater elevations in the Rambler Road residence area are several feet lower than at HN-9S, indicating that it is highly unlikely that the contamination in HN-9S is originating from the Rambler Road residence area.

Shallow groundwater flow interpretations made by the USGS for the Casey Village/Shenandoah Woods housing areas are provided in Figures 2 through 4 (Sloto, et.al., 1998). The depth interval for wells included in these maps is 18 to 64 feet, which encompasses the monitored intervals of both HN-9S (29 to 52 ft) and HN-62S (35 to 50 ft). The depths of the Rambler Road residential wells were 81 feet and approximately 70 to 90 feet, however the depths of water producing zones within the wells are not known. It is likely that both wells were open over most of the shallow depth interval targeted on these maps, based on standard domestic well construction practices (casing set to competent bedrock, then an open hole drilled to the total well depth). All three groundwater flow maps, spanning the 1995 to 1996 time period, indicate the presence of a groundwater divide in the vicinity of well HN-9S. Figures 3 and 4 show the divide to be aligned in a NNW-SSE direction, with shallow groundwater migrating to the east and southwest from the area of the divide. A more recent (1998) potentiometric surface map prepared for Shenandoah Woods and Area B (Figure 5) shows a decreasing hydraulic potential from the Shenandoah Woods/Casey Village boundary area to the west, i.e., the groundwater elevation at HN-9S is higher than at HN-62S, which is higher than at HN-5S. This again suggests that the carbon tetrachloride in these wells originates from somewhere near the Shenandoah Woods/Casey Village boundary area, either on or offbase.

Contaminant Source(s)

There is no obvious source for the carbon tetrachloride contamination. A common source for the two areas of elevated carbon tetrachloride detections may be in the general area of HN-9S, either within Casey Village or on the Navy property. The extent of carbon tetrachloride impacts is limited, as there are a number of wells located in the immediate vicinities of the impacted wells that have trace to no concentrations of carbon tetrachloride (Figure 1).

None of the Area B (Sites 5, 6, and 7) monitoring wells have had positive detections of carbon tetrachloride in any of the numerous rounds of sampling performed over the past 10 years. The only onbase wells with carbon tetrachloride detections (HN-9S, HN-62S, HN-5S, and HN-5D) are in middle to eastern portion of the Shenandoah Woods housing area, east of Area B (Table 2). Groundwater elevations among these wells decrease from east to west, from HN-9S to HN-5S/5D heading in the direction towards Area B, indicating that the potential for groundwater flow from the impacted wells is towards, not coming from, Area B. The lowest concentrations of carbon tetrachloride among these wells are in cluster HN-5S/5D, which is the nearest of the impacted well clusters to Area B. HN-5S has had one detection of carbon tetrachloride at 0.5 ug/L in three rounds of sampling, while HN-5D had one detection of 2 ug/L in two rounds of sampling. Groundwater flow data for Area B indicates groundwater flow across these sites to the south, away from the impacted wells in Shenandoah Woods and Casey Village. Based on

the combination of groundwater elevation data and contaminant concentration trends, Area B is not a source for the observed carbon tetrachloride contamination.

Risk Evaluation

The carbon tetrachloride data was evaluated to determine the potential for adverse health effects under a potential residential exposure scenario. Groundwater sampling results from 01/94 through 06/00 were evaluated (EPA, 2000; see Appendix A). Two monitoring wells in close proximity to each other (HN-09S and HN-62S) were found to consistently contain the highest concentrations of carbon tetrachloride over this time period. For the purpose of estimating upper bound risks, analytical results from these wells were combined to first predict data distribution (normal versus log normal) and, subsequently, to calculate a potential exposure point concentration for carbon tetrachloride.

For children, ingestion of groundwater and dermal contact while bathing were considered to be potentially viable routes of exposure under a future land-use scenario. For adults, exposure via ingestion and inhalation (during showering) was assessed.

Potential risks – both non-cancer and cancer - were estimated:

- Non-cancer risks are expressed in terms of a Hazard Quotient (HQ). The sum of HQ values from all exposure pathways and routes is referred to as the Hazard Index (HI). For similar target organs or endpoints of toxicity, an HI value less than one implies that detrimental non-cancer effects are not expected to occur.

- Carcinogenic risks are described as the probability of developing cancer from exposure to site-related contaminants. EPA typically defines excess cancer risks within the range of 1E-06 to 1E-04 (or less) to be acceptable, with 1E-06 being the point-of-departure. Action to mitigate a risk is generally taken by EPA when the risk posed by a site surpasses 1E-04, which translates to 1 additional chance in ten thousand of developing cancer.

Based on the risk evaluation and conservative assumptions related to exposure, neither future child residents (HI = 0.9) nor future adult residents (HI = 0.4) are expected to experience adverse health impacts due to carbon tetrachloride in groundwater in this case. Further, the potential cumulative cancer risk to future residents (2.0E-5) falls within EPA's generally accepted limits.

Summary

Based on the investigation results and risk evaluation summarized above, the nature and extent of the carbon tetrachloride in groundwater has been characterized, the groundwater of interest does not pose an unacceptable risk, and no further investigation is necessary.

Trichloroethene Issue

Contaminant Distribution

Trichloroethene (TCE) has been detected in a number of residential and monitoring wells located in Casey Village and in the adjacent Shenandoah Woods housing area. Based on historic sampling data (see Tables 1 and 2), the highest overall concentrations of TCE (1,200 ug/L) have been detected in Casey Village, on two different occasions in 1993 and 1994 in a residential well located at 1105 Orchid Road. The overall distribution of TCE is somewhat limited, as evidenced by the TCE concentrations shown in Figures 6 (1993-1994 data) and 7 (1996 data).

Figure 8 shows a general depiction of the TCE plume, based on sampling results through 1996. As indicated on Figure 8, the plume has an elliptical shape, extending preferentially in an east-west direction.

The highest TCE concentration detected in the Shenandoah Woods development (120 ug/L) was in monitoring well HN-49I, located along the boundary road between Casey Village and Shenandoah Woods. Monitoring well HN-61S, located west of HN-49I, has the next highest TCE concentration of Shenandoah Woods area monitoring wells, typically in the 40-50 ug/L range over the course of 8 rounds of sampling. Aside from these two wells, TCE concentrations in Shenandoah Woods monitoring wells, including clusters HN-5S/I/D, HN-6S/I/D, HN-7S/I/D, HN-8S/I/D, HN-9S/I/D, HN-49S, HN-61I, HN-62S/I, HN-84S/I, and HN-85S/I, have been at trace to nondetect levels (primarily nondetect) with three exceptions. TCE levels in HN-7S and HN-7I have generally been in the 5 to 9 ug/L range over the 1994 to 1998 time span, and the TCE level in HN-6S was reported by the USGS to be 16 ug/L in 1996 (Navy sampling results from 1994, 1996, 1997, and 1998 in this well have been nondetect for TCE). Table 2 provides a summary of the groundwater monitoring results for Navy monitoring wells in the Shenandoah Woods area.

Groundwater Flow Patterns

USGS groundwater flow interpretations for the Casey Village/Shenandoah Woods area (Figures 9, 10, and 11) show a groundwater divide in the area near the boundary between the two housing developments. The precise location of the groundwater divide is not known, but the water level data indicates that groundwater migrates to the southwest and to the north-northeast from the area of the divide. USGS water level data for wells HN-49I (screened from 55-75 feet in depth) and HN-61S (screened from 81-95 feet in depth), the two most impacted Navy monitoring wells, shows that groundwater flow is predominantly from well HN-49I towards HN-61S. In addition, the water level in former residential well BK 2795, located along Orchid Road, is higher than the water levels in either HN-49I or HN-61S.

More recent (1998) groundwater flow data for the Shenandoah Woods area (Figure 12) also indicates that groundwater flows from the vicinity of HN-49I (groundwater elevation 331.03 ft), located along the Shenandoah Woods/Casey Village boundary, to HN-61S (groundwater elevation 329.41 ft). This, in combination with the concentration gradient observed among these two wells and residential well BK 2799, indicates that the TCE found in HN-49I and HN-61S is migrating from the Casey Village area.

Data collected from pumping tests performed by the USGS in October 1996 reveal that the pumping of BK-2799 creates elliptical drawdown patterns trending east-west or east-southeast to west-northwest, depending on depth. A significant hydraulic connection between BK-2799, HN-49I, and HN-61S was observed, further tying together the water level and contaminant data for these wells.

Effects of Residential Well Usage

The groundwater flow maps reflect flow conditions at time periods after the residential wells within Casey Village had been permanently abandoned. It should be noted, however, that during a portion of the time period that the residential wells were in use, there was likely very little net loss of water from the groundwater flow system. Up until 1979, houses within Casey Village use septic systems for disposal of household wastewaters generated, thus the pumping of groundwater for domestic uses was accompanied by the discharge of water from the septic systems and subsequent recharge to the groundwater system.

The USGS estimated that an average of approximately 8,300 gallons of water per day (a total withdrawal rate averaging about 5.8 gpm, or 3 million gallons per year) was pumped by the 50 Casey Village wells, assuming 2.9 residents per house and 57 gallons per day usage of water per resident (Sloto, et.al., 1998). The area covered by Casey Village is approximately 3.25 million square feet (Bennett, 1996). Based on an average recharge rate of 11 inches per year (Sloto and Davis, 1983), the annual recharge to groundwater in Casey Village is about 22.1 million gallons (Bennett, 1996), or 7x the rate of groundwater usage. Obviously, based on these flow volumes, local groundwater recharge greatly exceeded local groundwater use and the net flux of groundwater in Casey Village was out into adjacent areas, even during the time period when the residential wells were in operation and after septic system use had been halted.

In early 1994, prior to the shutdown of the residential wells, the Navy performed a month-long water level study to see what effects the pumping of residential wells in Casey Village had on groundwater levels onbase. Two monitoring well clusters along the boundary between Casey Village and Shenandoah Woods were monitored for this purpose. The conclusion of the study was that the operation of the residential wells had negligible effects on groundwater levels in monitoring wells located along the boundary between Casey Village and Shenandoah Woods (Halliburton NUS, 1995). Based on the results of the water level study, the intermittent pumping of the residential wells in Casey Village most likely did not alter groundwater flow patterns in the adjacent Navy housing area.

Contaminant Source(s)

Available information indicates that the release or source responsible for the TCE groundwater contamination in the Casey Village area may have been in the vicinity of residential well BK-2799, where the highest TCE levels have historically been detected in groundwater. The USGS, in their investigation of groundwater contamination in the Casey Village area, postulated that the pumping of residential wells located between 1105 Orchid Road and the base boundary may have pulled TCE contamination from the vicinity of BK-2799 to the west into the groundwater divide area, where it subsequently migrated to both the west and east under the natural gradient (Sloto, et.al., 1998).

Since the use of well BK-2799 for domestic water supply was halted in late 1994, TCE concentrations in the well have declined from the initial level of 1,200 ug/L, indicating that the well is not located directly downgradient of the source of the contamination. The USGS, in two rounds of sampling of the well conducted in 1996, found TCE concentrations of 450 and 140 ug/L (March and October, respectively).

Packer sampling of the well by the USGS in October 1996 indicated that TCE concentrations decreased with depth. Geophysical logging indicated that borehole flow under nonpumping conditions is into the well from lower fractures and then upward in the borehole and out into the formation through shallow fractures. The combination of upward flow and lower TCE concentrations at depth was postulated by the USGS to be at least a factor in the significant decline in TCE levels in the well over the 1994 to 1996 time frame.

Time-series sampling results from samples collected after 1, 3, and 5 hours of pumping of this well in October 1996 showed a rise in TCE concentrations over time from 120 to 180 ug/L (Sloto, et.al., 1998). This rise in concentration suggests that extended operation of the well pulls in contamination from a nearby location.

Summary

Based on the data from the investigations performed by the Navy and USGS in the Casey Village/Shenandoah Woods area as summarized above, the TCE contamination present in groundwater underlying Casey Village and part of the Shenandoah Woods housing area does not appear attributable to releases on NAWC property. Investigation results supporting this conclusion are summarized as follows:

- The maximum TCE concentrations found were in the Casey Village housing area and were at a level 10x higher than any concentration found in the adjacent Shenandoah Woods area. Contaminant concentrations decrease with increasing distance away from this hot spot, consistent with typical plume behavior.

- Groundwater flow in the area of TCE contamination within the eastern portion of Shenandoah Woods near the boundary with Casey Village is inward (to the southwest) towards the interior of Shenandoah Woods, suggesting that the contamination originates somewhere to the east of Shenandoah Woods.

- Groundwater elevation data indicate that a groundwater divide exists in the general area of the TCE plume. The divide, coupled with the historic pumping of domestic wells, supports the observed distribution of TCE and plume migration in two directions.

It is recommended that the results of these investigations be referred to the EPA and PADEP for any further action.

REFERENCES

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Sloto, Ronald A., and D.K. Davis, 1983. Effect of Urbanization on the Water Resources of Warminster Township, Bucks County, Pennsylvania. USGS Water-Resources Investigations 82-4020, Lakewood, Colorado.

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TABLES

TABLE 1
CASEY VILLAGE AREA
RESIDENTIAL WELLS
POSITIVE VOC DETECTIONS, PRETREATMENT SAMPLES
NAWC WARMINSTER

Well No.	1	1	1	2	3	4	4	4	5	5	5	6	6	6
Address	1055 Azalea	1055 Azalea	1055 Azalea	1065 Azalea	1069 Azalea	1080 Azalea	1080 Azalea	1080 Azalea	1085 Azalea	1085 Azalea	1085 Azalea	1093 Azalea	1093 Azalea	1093 Azalea
Name/USGS No.	Koelzer			Martin	Smith		Dershimer			Walter			Nomes	
	5/17/1993	5/17/1993	10/11/1993	5/14/1993	4/28/1993	4/28/1993	6/27/1994	6/27/1994	5/17/1993	10/11/1993	6/28/1994	5/18/1993	10/8/1993	3/10/1994
COMPOUND	W-0S-24	W-0S-24D	W-0S-308	W-OS-19	W-OS-12	W-OS-10	W-OS-456	W-OS-456D	W-OS-26	W-OS-301	W-OS-483	W-OS-36	W-OS-292	W-OS-363
1,1-DICHLOROETHENE				4.6		0.9 J			0.7 J	1		1	2	
1,1-DICHLOROETHANE												0.4 J		
CIS-1,2-DICHLOROETHENE (or TOTAL)														
TRANS-1,2-DICHLOROETHENE														
CHLOROFORM			1	0.5 J										
1,2-DICHLOROETHANE		0.2 J												
1,1,1-TRICHLOROETHANE	3	3.2	14	7.5		1 J			1.6	2	4	0.7 J		
CARBON TETRACHLORIDE														
TRICHLOROETHENE				0.3 J								0.2 J		
1,1,2-TRICHLOROETHANE												0.2 J		
BENZENE														
TETRACHLOROETHENE	3.3	3.4	3	110		20	11	12	41	55	62	2.1	2	3
TOLUENE												0.58		

All data from Halliburton NUS off-base well inventory and sampling program conducted for US Navy.
Concentrations reported in ug/l
Blank cell = non detect
J = estimated concentration
W-xx-xxD = Duplicate

TABLE 1
CASEY VILLAGE AREA
RESIDENTIAL WELLS
POSITIVE VOC DETECTIONS, PRETREATMENT SAMPLES
NAWC WARMINSTER

Well No.	7	7	7	7	8	8	8	8	9	9	9	9	10	10
Address	1096 Azalea	1096 Azalea	1096 Azalea	1096 Azalea	1103 Azalea	1103 Azalea	1103 Azalea	1103 Azalea	1106 Azalea	1106 Azalea	1106 Azalea	1106 Azalea	1113 Azalea	1113 Azalea
Name/USGS No.	Jenceleski				Meisner				Neumann				Wilkinson	
	5/17/1993	10/12/1993	3/23/1994	6/28/1994	5/18/1993	10/12/1993	3/17/1994	6/27/1994	5/18/1993	10/8/1993	3/10/1994	7/1/1994	5/14/1993	10/21/1993
COMPOUND	W-OS-28	W-OS-315	W-OS-408	W-OS-488	W-OS-47	W-OS-322	W-OS-394	W-OS-466	W-OS-40	W-OS-293	W-OS-364	W-OS-513	W-OS-20	W-OS-324
1,1-DICHLOROETHENE	0.1 J				0.1 J									
1,1-DICHLOROETHANE														
CIS-1,2-DICHLOROETHENE (or TOTAL)									0.4 J				0.5 J	
TRANS-1,2-DICHLOROETHENE														
CHLOROFORM														
1,2-DICHLOROETHANE														
1,1,1-TRICHLOROETHANE	0.3 J				0.4 J									
CARBON TETRACHLORIDE														
TRICHLOROETHENE	0.2 J								0.4 J				0.3 J	
1,1,2-TRICHLOROETHANE														
BENZENE														
TETRACHLOROETHENE	1.7	2	2	4					0.5 J				0.7 J	
TOLUENE					0.58									

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POSITIVE VOC DETECTIONS, PRETREATMENT SAMPLES
NAWC WARMINSTER

Well No.	10	10	10	11	11	12	12	12	12	13	57	59	59
Address	1113 Azalea	1113 Azalea	1113 Azalea	1116 Azalea	1116 Azalea	1125 Azalea	1125 Azalea	1125 Azalea	1125 Azalea	1126 Azalea	974 Davisville	1066 Davisville	1066 Davisville
Name/USGS No.	Wilkinson			James/BK 2790, 2796		Hopely				Reese/BK 2800	Cardellino	Russell	
	3/10/1994	3/10/1994	6/28/1994	5/17/1993	10/11/1993	5/14/1993	10/11/1993	3/17/1994	6/27/1994	5/17/1993	6/17/1993	6/9/1993	10/7/1993
COMPOUND	W-OS-358	W-OS-358D	W-OS-487	W-OS-27	W-OS-304	W-OS-21	W-OS-307	W-OS-397	W-OS-464	W-OS-25	W-OS-130	W-OS-82	W-OS-285
1,1-DICHLOROETHENE													
1,1-DICHLOROETHANE													
CIS-1,2-DICHLOROETHENE (or TOTAL)										27			
TRANS-1,2-DICHLOROETHENE	1	1		3	3	1	1	1		1.1			
CHLOROFORM													
1,2-DICHLOROETHANE										0.2 J			
1,1,1-TRICHLOROETHANE													
CARBON TETRACHLORIDE													
TRICHLOROETHENE				3.9	5	0.6 J				64		0.3 J	
1,1,2-TRICHLOROETHANE													
BENZENE													
TETRACHLOROETHENE						1.3	3		1			3.1	8
TOLUENE													

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Concentrations reported in ug/l
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J = estimated concentration
W-xx-xxD = Duplicate

TABLE 1
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RESIDENTIAL WELLS
POSITIVE VOC DETECTIONS, PRETREATMENT SAMPLES
NAWC WARMINSTER

Well No.	60	60	60	60	61	61	62	62	63	63	63
Address	1074 Davisville	1074 Davisville	1074 Davisville	1074 Davisville	1084 Davisville	1084 Davisville	1094 Davisville	1094 Davisville	1104 Davisville	1104 Davisville	1104 Davisville
Name/USGS No.	Farina/BK 2769				Cibc		Carr		DiBattista		
	6/16/1993	6/29/1993	7/14/1993	7/14/1993	6/9/1993	3/24/1994	6/9/1993	3/17/1994	6/8/1993	10/11/1993	3/15/1994
COMPOUND	W-OS-115	W-OS-191	W-OS-230	W-OS-231	W-OS-81	W-OS-407	W-OS-80	W-OS-399	W-OS-73	W-OS-311	W-OS-391
1,1-DICHLOROETHENE	19	23	21		8.1	6	1.6				
1,1-DICHLOROETHANE	2	2	2		0.8 J		0.7 J				
CIS-1,2-DICHLOROETHENE (or TOTAL)	2	2	2		0.9 J						
TRANS-1,2-DICHLOROETHENE											
CHLOROFORM											
1,2-DICHLOROETHANE											
1,1,1-TRICHLOROETHANE	35	45 J	33	26	19	16	1.6				
CARBON TETRACHLORIDE											
TRICHLOROETHENE	7	8	8		3.4	4	0.9 J		1.5	2	1
1,1,2-TRICHLOROETHANE					0.4 J						
BENZENE											
TETRACHLOROETHENE	480	560 J	720	570	440	470	75		1.4	2	1
TOLUENE											

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Concentrations reported in ug/l
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J = estimated concentration
W-xx-xxD = Duplicate

TABLE 1
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RESIDENTIAL WELLS
POSITIVE VOC DETECTIONS, PRETREATMENT SAMPLES
NAWC WARMINSTER

Well No.	64	64	65	66	67	68	69	.70	92	163	163	163
Address	1115 Davisville	1115 Davisville	1255 Davisville	1291 Davisville	1315 Davisville	1335 Davisville	1345 Davisville	1365 Davisville	9 Hogeland	1063 Orchid	1063 Orchid	1063 Orchid
Name/USGS No.	Niles		Bangs	Mackey	Thomas	Roberts	Sokolowski	Nankerville/BK 2788	Hays/BK 2791, 2797	Johnston		
	6/8/1993	6/8/1993	6/8/1993	6/15/1993	6/9/1993	6/8/1993	6/9/1993	6/7/1993	6/21/1993	4/28/1993	10/7/1993	10/7/1993
COMPOUND	W-OS-61	W-OS-61D	W-OS-65	W-OS-112	W-OS-77	W-OS-66	W-OS-78	W-OS-60	W-OS-152	W-OS-11	W-OS-278	W-OS-278D
1,1-DICHLOROETHENE	0.2 J					0.7 J	0.6 J	5.4	1			
1,1-DICHLOROETHANE												
CIS-1,2-DICHLOROETHENE (or TOTAL)								0.6 J				
TRANS-1,2-DICHLOROETHENE												
CHLOROFORM												
1,2-DICHLOROETHANE												
1,1,1-TRICHLOROETHANE						2.5	1.8	16	2	1 J	1 J	
CARBON TETRACHLORIDE				5								
TRICHLOROETHENE	0.2 J					0.4 J	1.3 J	2				
1,1,2-TRICHLOROETHANE												
BENZENE												
TETRACHLOROETHENE	7.5	7			8.2	52	27	440		2	2	2
TOLUENE	0.8 J	1.5	0.6 J			0.5 J						

All data from Halliburton NUS off-base well inventory and sampling program conducted for US Navy.
Concentrations reported in ug/l
Blank cell = non detect
J = estimated concentration
W-xx-xxD = Duplicate

TABLE 1
CASEY VILLAGE AREA
RESIDENTIAL WELLS
POSITIVE VOC DETECTIONS, PRETREATMENT SAMPLES
NAWC WARMINSTER

Well No.	163	164	164	165	166	166	167	167	168	168	168	169	169	170
Address	1063 Orchid	1095 Orchid	1095 Orchid	1100 Orchid	1105 Orchid	1105 Orchid	1115 Orchid	1115 Orchid	1130 Orchid	1130 Orchid	1130 Orchid	1150 Orchid	1150 Orchid	9 Rambler
Name/USGS No.	Johnston	Parabek/BK2798		Reiss/BK 2767, 2795	Stevens/BK 2799		Sabol		Tata			McGuigan		Finnegan
	3/11/1994	5/18/1993	8/17/1994	6/7/1993	6/24/1993	8/17/1994	5/18/1993	5/18/1993	5/14/1993	10/8/1993	3/15/1994	6/12/1993	10/21/1993	6/8/1993
COMPOUND	W-OS-375	W-OS-46	W-OS-533	W-OS-54	W-OS-173	W-OS-534	W-OS-45	W-OS-45D	W-OS-22	W-OS-299	W-OS-389	W-OS-89	W-OS-334	W-OS-64
1,1-DICHLOROETHENE														1.9
1,1-DICHLOROETHANE														
CIS-1,2-DICHLOROETHENE (or TOTAL)		35	26	36	530	550	25	30						
TRANS-1,2-DICHLOROETHENE				0.2J	3	3								
CHLOROFORM		0.1 J												
1,2-DICHLOROETHANE														
1,1,1-TRICHLOROETHANE	1	0.2 J												3.6
CARBON TETRACHLORIDE												0.2J		
TRICHLOROETHENE		89	49	120	1200	1200	87	100						1
1,1,2-TRICHLOROETHANE														
BENZENE														50
TETRACHLOROETHENE	2	0.1 J			1									
TOLUENE														

All data from Halliburton NUS off-base well inventory and sampling program conducted for US Navy.
Concentrations reported in ug/l
Blank cell = non detect
J = estimated concentration
W-xx-xxD = Duplicate

TABLE 1
CASEY VILLAGE AREA
RESIDENTIAL WELLS
POSITIVE VOC DETECTIONS, PRETREATMENT SAMPLES
NAWC WARMINSTER

Well No.	170	170	171	172	172	172	173	173	174	174	174	175	175	175
Address	9 Rambler	9 Rambler	26 Rambler	715 Rambler	715 Rambler	715 Rambler	718 Rambler	718 Rambler	727 Rambler	727 Rambler	727 Rambler	737 Rambler	737 Rambler	737 Rambler
Name/USGS No.	Finnegan		Puente	Hood			Clawges		Greenstreet			Finegan		
	6/30/1993	7/14/1993	6/9/1993	5/17/1993	10/11/1993	3/23/1994	5/18/1993	5/11/1994	5/17/1993	6/27/1994	6/27/1994	5/17/1993	6/27/1994	6/27/1994
COMPOUND	W-OS-203	W-OS-233	W-OS-83	W-OS-31	W-OS-302	W-OS-414	W-OS-37	W-OS-441	W-OS-29	W-OS-471	W-OS-471D	W-OS-30	W-OS-467	W-OS-467D
1,1-DICHLOROETHENE	1J		1J											
1,1-DICHLOROETHANE														
CIS-1,2-DICHLOROETHENE (or TOTAL)							50	3	2.7	2	2	3	2	2
TRANS-1,2-DICHLOROETHENE							0.6J							
CHLOROFORM														
1,2-DICHLOROETHANE														
1,1,1-TRICHLOROETHANE	4	2J	3.6											
CARBON TETRACHLORIDE				0.2J					6.9	6	6	8.7	6	6
TRICHLOROETHENE		1J	0.3J				15		3	3	3	3.2	2	2
1,1,2-TRICHLOROETHANE														
BENZENE														
TETRACHLOROETHENE	42	37	60											
TOLUENE														

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Concentrations reported in ug/l
Blank cell = non detect
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TABLE 1
CASEY VILLAGE AREA
RESIDENTIAL WELLS
POSITIVE VOC DETECTIONS, PRETREATMENT SAMPLES
NAWC WARMINSTER

Well No.	176	176	176	176	177	178	178	178	178	178	179	179	179
Address	747 Rambler	747 Rambler	747 Rambler	747 Rambler	757 Rambler	767 Rambler	767 Rambler	767 Rambler	767 Rambler	767 Rambler	777 Rambler	777 Rambler	777 Rambler
Name/USGS No.	Wolf/BK 2787				Pellichero	Wagner					Roberts		
	5/18/1993	10/8/1993	3/23/1994	6/27/1994	6/7/1993	6/7/1993	6/7/1993	10/8/1993	10/8/1993	3/15/1994	5/18/1993	6/22/1993	6/27/1994
COMPOUND	W-OS-44	W-OS-288	W-OS-410	W-OS-452	W-OS-53	W-OS-52	W-OS-52D	W-OS-287	W-OS-287D	W-OS-379	W-OS-43	W-OS-161	W-OS-469
1,1-DICHLOROETHENE											0.2J		
1,1-DICHLOROETHANE											20	14	17
CIS-1,2-DICHLOROETHENE (or TOTAL)	2.8	5		3	4.1	1.7	1.8	2	2		0.2J		
TRANS-1,2-DICHLOROETHENE													
CHLOROFORM													
1,2-DICHLOROETHANE													
1,1,1-TRICHLOROETHANE		1			0.3J								
CARBON TETRACHLORIDE	1.5			1									
TRICHLOROETHENE	0.1	3	2	2	7	1	1	2J	1		4.4	3	4
1,1,2-TRICHLOROETHANE													
BENZENE													
TETRACHLOROETHENE													
TOLUENE													

All data from Halliburton NUS off-base well inventory and sampling program conducted for US Navy.
Concentrations reported in ug/l
Blank cell = non detect
J = estimated concentration
W-xx-xxD = Duplicate

TABLE 1
CASEY VILLAGE AREA
RESIDENTIAL WELLS
POSITIVE VOC DETECTIONS, PRETREATMENT SAMPLES
NAWC WARMINSTER

Well No.	180	180	181	181	189	190	191	192	193	194	195	195	196
Address	786 Rambler	786 Rambler	789 Rambler	789 Rambler	1286 Rosebud	1292 Rosebud	1306 Rosebud	1307 Rosebud	1317 Rosebud	1326 Rosebud	1327 Rosebud	1327 Rosebud	1336 Rosebud
Name/USGS No.	Kenkelen/BK 2789		Kulb		Wittwer	Bruder	Mack	Leach	Shorn	Strybuc	Cerquitella/BK 2770		Hoffman
	5/18/1993	7/1/1994	5/17/1993	5/17/1993	6/8/1993	6/8/1993	6/16/1993	6/15/1993	6/14/1993	6/7/1993	6/9/1993	6/9/1993	6/8/1993
COMPOUND	W-OS-39	W-OS-510	W-OS-32	W-OS-317	W-OS-117	W-OS-354	W-OS-380	W-OS-103	W-OS-101	W-OS-59	W-OS-76	W-OS-76D	W-OS-70
1,1-DICHLOROETHENE	1.5												
1,1-DICHLOROETHANE	0.8J											0.3J	
CIS-1,2-DICHLOROETHENE (or TOTAL)	0.4J		1.4	1									
TRANS-1,2-DICHLOROETHENE													
CHLOROFORM													
1,2-DICHLOROETHANE													
1,1,1-TRICHLOROETHANE	1												
CARBON TETRACHLORIDE													
TRICHLOROETHENE	0.9J	1	1.1	2									
1,1,2-TRICHLOROETHANE										0.2J			
BENZENE													
TETRACHLOROETHENE	57	61	2.9	7									
TOLUENE													

All data from Halliburton NUS off-base well inventory and sampling program conducted for US Navy.
Concentrations reported in ug/l
Blank cell = non detect
J = estimated concentration
W-xx-xxD = Duplicate

TABLE 1
CASEY VILLAGE AREA
RESIDENTIAL WELLS
POSITIVE VOC DETECTIONS, PRETREATMENT SAMPLES
NAWC WARMINSTER

Well No.	197	198	199	199	200	214	215	216	218	219	219	220	221
Address	1337 Rosebud	1346 Rosebud	1366 Rosebud	1366 Rosebud	1416 Rosebud	190 W Bristol	200 W Bristol	235 W Bristol	245 W Bristol	255 W Bristol	255 W Bristol	277 W Bristol	305 W Bristol
Name/USGS No.	Merkov	Thoman	Merkle		Gloser		Fallows	Donahue	Magro	Bongart		Hull	Tanner
	6/9/1993	6/8/1993	6/9/1993	7/2/1993	6/8/1993	7/13/1993	7/13/1993	6/23/1993	6/23/1993	6/23/1993	6/23/1993	6/23/1993	6/22/1993
COMPOUND	W-OS-75	W-OS-69	W-OS-84	W-OS-212	W-OS-68	W-OS-220	W-OS-219	W-OS-167	W-OS-165	W-OS-166	W-OS-166D	W-OS-171	W-OS-158
1,1-DICHLOROETHENE					0.3J								
1,1-DICHLOROETHANE					0.8J								
CIS-1,2-DICHLOROETHENE (or TOTAL)													
TRANS-1,2-DICHLOROETHENE													
CHLOROFORM													
1,2-DICHLOROETHANE													
1,1,1-TRICHLOROETHANE			0.8J		1.6								
CARBON TETRACHLORIDE													
TRICHLOROETHENE			0.2J										
1,1,2-TRICHLOROETHANE													
BENZENE													
TETRACHLOROETHENE		0.6J	21	12	14								
TOLUENE													

All data from Halliburton NUS off-base well inventory and sampling program conducted for US Navy.
Concentrations reported in ug/l
Blank cell = non detect
J = estimated concentration
W-xx-xxD = Duplicate

TABLE 1
CASEY VILLAGE AREA
RESIDENTIAL WELLS
POSITIVE VOC DETECTIONS, PRETREATMENT SAMPLES
NAWC WARMINSTER

Well No.	222	223	224	225	226	227
Address	315 W Bristol	325 W Bristol	335 W Bristol	345 W Bristol	355 W Bristol	365 W Bristol
Name/USGS No.	Bentz	McFarland	Nee	Celia	McManamin	Wolstenholmes
	6/22/1993	6/22/1993	6/29/1993	6/22/1993	6/24/1993	6/23/1993
COMPOUND	W-OS-159	W-OS-163	W-OS-196	W-OS-162	W-OS-180	W-OS-172
1,1-DICHLOROETHENE						
1,1-DICHLOROETHANE						
CIS-1,2-DICHLOROETHENE (or TOTAL)						
TRANS-1,2-DICHLOROETHENE						
CHLOROFORM						
1,2-DICHLOROETHANE						
1,1,1-TRICHLOROETHANE						
CARBON TETRACHLORIDE						
TRICHLOROETHENE						
1,1,2-TRICHLOROETHANE						
BENZENE						
TETRACHLOROETHENE						
TOLUENE						

All data from Halliburton NUS off-base well inventory and sampling program conducted for US Nav
Concentrations reported in ug/l
Blank cell = non detect
J = estimated concentration
W-xx-xxD = Duplicate

TABLE 2
SHENANDOAH WOODS MONITORING WELLS
SUMMARY OF
POSITIVE VOC DETECTIONS
NAWC WARMINSTER

COMPOUND	HN-05S Shallow			HN-05I Inter			HN-05D Deep		HN-06S Shallow				HN-06I Inter			HN-06D Deep		
	01/94 [1]	6/98 [2]	06/00 [3]	01/94 [1]	6/98 [2]	06/00 [3]	01/94 [1]	6/98 [2]	01/94 [1]	10/96 [4]	03/97 [4]	6/98 [2]	01/94 [1]	03/97 [4]	6/98 [2]	01/94 [1]	03/97 [4]	6/98 [2]
CARBON DISULFIDE					2			2										
1,1-DICHLORCETHENE										2		2						
1,1-DICHLOROETHANE											0.5 J							
CIS-1,2-DICHLOROETHENE (or TOTAL)																		
CHLOROFORM																		
1,1,1-TRICHLOROETHANE											0.2 J							
CARBON TETRACHLORIDE			0.48J				2											
TRICHLOROETHENE											0.5 J							
TETRACHLOROETHENE			0.16J						9	18	12	16		0.1 J				
TOLUENE				8			5									10		
TRICHLOROFLUOROMETHANE																		

Concentrations reported in ug/l
Blank cell = non detect
J = estimated concentration
(1) Halliburton NUS Area B Hydrogeologic Report, April 1995.
(2) TetraTech NUS Summary Report for Area B Groundwater Monitoring, October 1998.
(3) TetraTech NUS supplemental sampling conducted in June 2000.
(4) Navy Perimeter Monitoring Program 12/94 to ongoing, various Perimeter Monitoring Reports.
(5) Brown & Root Environmental Navy Enlisted Housing Area Well Installation and Sampling, July 1998.

TABLE 2
SHENANDOAH WOODS MONITORING WELLS
SUMMARY OF
POSITIVE VOC DETECTIONS
NAWC WARMINSTER

COMPOUND	HN-07S Shallow			HN-07I Inter			HN-07D Deep		HN-08S Shallow					
	01/94 [1]	10/96 [4]	6/98 [2]	01/94 [1]	10/96 [4]	6/98 [2]	01/94 [1]	6/98 [2]	01/94 [1]	12/94 [4]	07/95 [4]	09/95 [4]	10/96 [4]	6/98 [2]
CARBON DISULFIDE														
1,1-DICHLOROETHENE														
1,1-DICHLOROETHANE									1					
CIS-1,2-DICHLOROETHENE (or TOTAL)	2	2	2	1	2	1								
CHLOROFORM													1	
1,1,1-TRICHLOROETHANE														
CARBON TETRACHLORIDE														
TRICHLOROETHENE	7	6	6	8	9		4							
TETRACHLOROETHENE														
TOLUENE				1			4J		9					
TRICHLOROFLUOROMETHANE														

Concentrations reported in ug/l
Blank cell = non detect
J = estimated concentration
(1) Halliburton NUS Area B Hydrogeologic Report, April 1995.
(2) TetraTech NUS Summary Report for Area B Groundwater Monitoring, October 1998.
(3) TetraTech NUS supplemental sampling conducted in June 2000.
(4) Navy Perimeter Monitoring Program 12/94 to ongoing, various Perimeter Monitoring Reports.
(5) Brown & Root Environmental Navy Enlisted Housing Area Well Installation and Sampling. July 1998.

TABLE 2
SHENANDOAH WOODS MONITORING WELLS
SUMMARY OF
POSITIVE VOC DETECTIONS
NAWC WARMINSTER

COMPOUND	HN-08I Inter					HN-08D Deep				HN-09S Shallow					
	01/94 [1]	12/94 [4]	07/95 [4]	09/95 [4]	6/98 [2]	01/94 [1]	07/95 [4]	09/95 [4]	6/98 [2]	01/94 [1]	04/95 [4]	01/96 [4]	10/96 [4]	6/98 [2]	12/98 [4]
CARBON DISULFIDE															
1,1-DICHLOROETHENE															
1,1-DICHLOROETHANE															
CIS-1,2-DICHLOROETHENE (or TOTAL)												1.5			1
CHLOROFORM						1						0.83			
1,1,1-TRICHLOROETHANE															
CARBON TETRACHLORIDE										8	7	9.4	6.5	8	8
TRICHLOROETHENE											2	2.2	1	1	4
TETRACHLOROETHENE															
TOLUENE						18									
TRICHLOROFLUOROMETHANE															

Concentrations reported in ug/l
Blank cell = non detect
J = estimated concentration
(1) Halliburton NUS Area B Hydrogeologic Report, April 1995.
(2) TetraTech NUS Summary Report for Area B Groundwater Monitoring, October 1998.
(3) TetraTech NUS supplemental sampling conducted in June 2000.
(4) Navy Perimeter Monitoring Program 12/94 to ongoing, various Perimeter Monitoring Reports.
(5) Brown & Root Environmental Navy Enlisted Housing Area Well Installation and Sampling, July 1998.

TABLE 2
SHENANDOAH WOODS MONITORING WELLS
SUMMARY OF
POSITIVE VOC DETECTIONS
NAWC WARMINSTER

COMPOUND	HN-09I Inter				HN-09D Deep				HN-49S Shallow									
	01/94 [1]	04/95 [4]	01/96 [4]	6/98 [2]	01/94 [1]	04/95 [4]	01/96 [4]	6/98 [2]	12/94 [4]	04/95 [4]	07/95 [4]	09/95 [4]	01/96 [4]	04/96 [4]	10/96 [4]	03/97 [4]	09/97 [4]	6/98 [2]
CARBON DISULFIDE											3							
1,1-DICHLOROETHENE																		
1,1-DICHLOROETHANE																		
CIS-1,2-DICHLOROETHENE (or TOTAL)																		
CHLOROFORM																		
1,1,1-TRICHLOROETHANE																		
CARBON TETRACHLORIDE																		
TRICHLOROETHENE									1									
TETRACHLOROETHENE																		
TOLUENE					5													
TRICHLOROFLUOROMETHANE																		

Concentrations reported in ug/l
Blank cell = non detect
J = estimated concentration
(1) Halliburton NUS Area B Hydrogeologic Report, April 1995.
(2) TetraTech NUS Summary Report for Area B Groundwater Monitoring, October 1998.
(3) TetraTech NUS supplemental sampling conducted in June 2000.
(4) Navy Perimeter Monitoring Program 12/94 to ongoing, various Perimeter Monitoring Reports.
(5) Brown & Root Environmental Navy Enlisted Housing Area Well Installation and Sampling, July 1998.

TABLE 2
SHENANDOAH WOODS MONITORING WELLS
SUMMARY OF
POSITIVE VOC DETECTIONS
NAWC WARMINSTER

COMPOUND	HN-49I Inter											
	12/94 [4]	04/95 [4]	07/95 [4]	09/95 [4]	01/96 [4]	04/96 [4]	10/96 [4]	03/97 [4]	09/97 [4]	6/98 [2]	12/98 [4]	06/99 [4]
CARBON DISULFIDE				45 J								
1,1-DICHLOROETHENE												
1,1-DICHLOROETHANE					8							
CIS-1,2-DICHLOROETHENE (or TOTAL)	30	33	28	29	31	31.5	36.5	17	23	30	30	30
CHLOROFORM												
1,1,1-TRICHLOROETHANE												
CARBON TETRACHLORIDE												
TRICHLOROETHENE	120	110	110	160	110	120	115	68	91	120	100	106
TETRACHLOROETHENE												
TOLUENE	12											
TRICHLOROFLUOROMETHANE							3.7				3	2.1

Concentrations reported in ug/l
Blank cell = non detect
J = estimated concentration
(1) Halliburton NUS Area B Hydrogeologic Report, April 1995.
(2) TetraTech NUS Summary Report for Area B Groundwater Monitoring, October 1998.
(3) TetraTech NUS supplemental sampling conducted in June 2000.
(4) Navy Perimeter Monitoring Program 12/94 to ongoing, various Perimeter Monitoring Reports.
(5) Brown & Root Environmental Navy Enlisted Housing Area Well Installation and Sampling, July 1998.

TABLE 2
SHENANDOAH WOODS MONITORING WELLS
SUMMARY OF
POSITIVE VOC DETECTIONS
NAWC WARMINSTER

COMPOUND	HN-49D Deep										HN-61S Shallow						
	12/94 [4]	04/95 [4]	07/95 [4]	09/95 [4]	01/96 [4]	04/96 [4]	10/96 [4]	03/97 [4]	09/97 [4]	6/98 [2]	01/96 [4]	10/96 [4]	03/97 [4]	09/97 [4]	6/98 [2]	12/98 [4]	06/99 [4]
CARBON DISULFIDE																	
1,1-DICHLOROETHENE																	
1,1-DICHLOROETHANE																	
CIS-1,2-DICHLOROETHENE (or TOTAL)	2	2									12	16	11	12	15	13	14
CHLOROFORM																	
1,1,1-TRICHLOROETHANE																	
CARBON TETRACHLORIDE																	
TRICHLOROETHENE	7	5		1	2				0 3 J		49	55	39	45	46	43	44
TETRACHLOROETHENE																	
TOLUENE	14																
TRICHLOROFLUOROMETHANE												2.8				2	1.5

Concentrations reported in ug/l
Blank cell = non detect
J = estimated concentration
(1) Halliburton NUS Area B Hydrogeologic Report, April 1995.
(2) TetraTech NUS Summary Report for Area B Groundwater Monitoring, October 1998.
(3) TetraTech NUS supplemental sampling conducted in June 2000.
(4) Navy Perimeter Monitoring Program 12/94 to ongoing, various Perimeter Monitoring Reports.
(5) Brown & Root Environmental Navy Enlisted Housing Area Well Installation and Sampling, July 1998.

TABLE 2
SHENANDOAH WOODS MONITORING WELLS
SUMMARY OF
POSITIVE VOC DETECTIONS
NAWC WARMINSTER

COMPOUND	HN-61I Deep				HN-62S Shallow						HN-62I Inter		HN-84S Shallow			HN-84I Deep	
	10/96 [4]	03/97 [4]	09/97 [4]	6/98 [2]	01/96 [4]	10/96 [4]	6/98 [2]	12/98 [4]	06/99 [4]	06/00 [3]	01/96 [4]	6/98 [2]	6/98 [2]	6/98 [5]	06/00 [3]	6/98 [2]	6/98 [5]
CARBON DISULFIDE				4									0.7				
1,1-DICHLOROETHENE																	
1,1-DICHLOROETHANE																	
CIS-1,2-DICHLOROETHENE (or TOTAL)																	
CHLOROFORM					0.54					0.36J							
1,1,1-TRICHLOROETHANE																	
CARBON TETRACHLORIDE					11	13	9	9	11J	6.6							
TRICHLOROETHENE		1	1		1.2					0.28J							
TETRACHLOROETHENE																	
TOLUENE																	
TRICHLOROFLUOROMETHANE																	

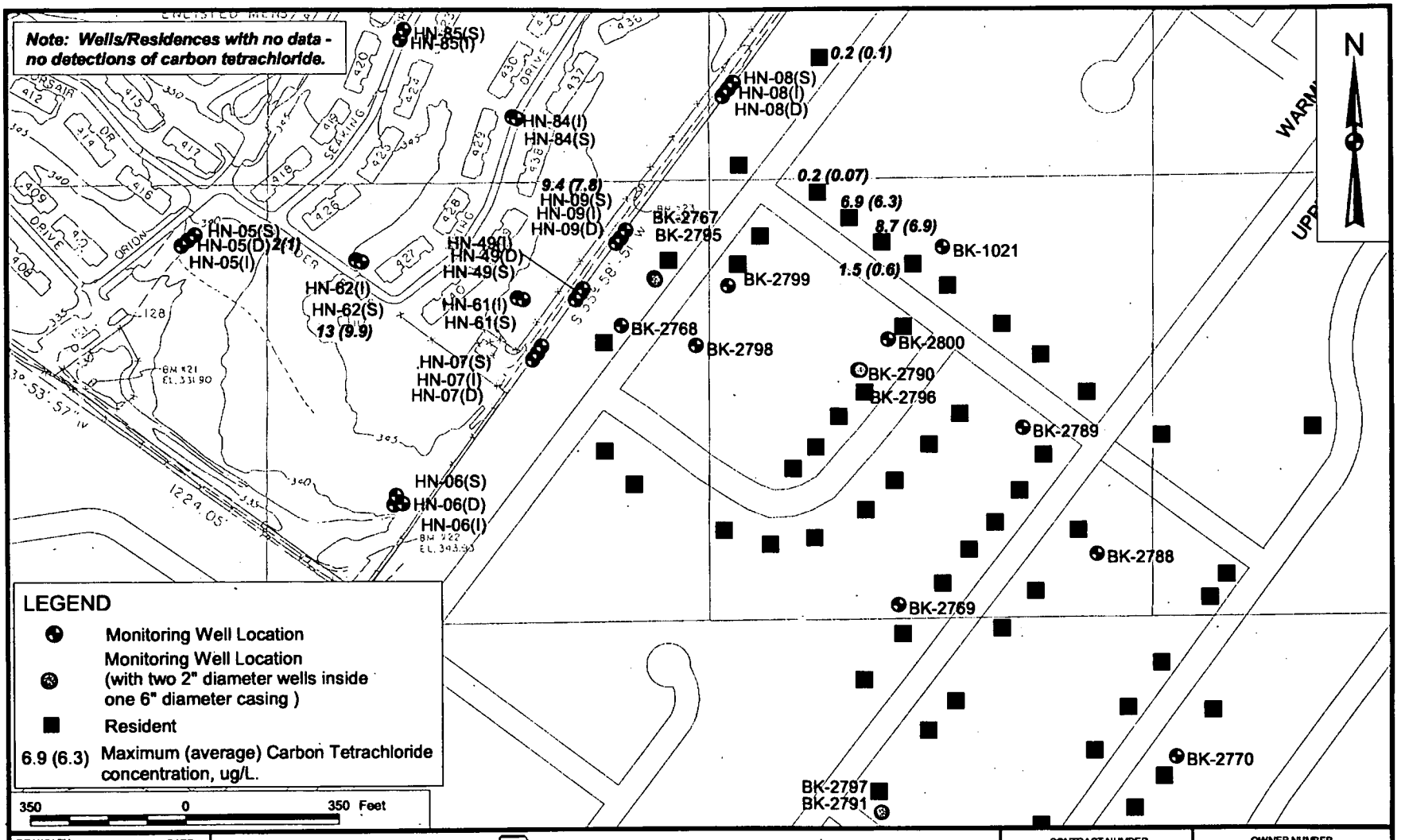
Concentrations reported in ug/l
Blank cell = non detect
J = estimated concentration
(1) Halliburton NUS Area B Hydrogeologic Report, April 1995.
(2) TetraTech NUS Summary Report for Area B Groundwater Monitoring, October 1998.
(3) TetraTech NUS supplemental sampling conducted in June 2000.
(4) Navy Perimeter Monitoring Program 12/94 to ongoing, various Perimeter Monitoring Reports.
(5) Brown & Root Environmental Navy Enlisted Housing Area Well Installation and Sampling, July 1998.

TABLE 2
SHENANDOAH WOODS MONITORING WELLS
SUMMARY OF
POSITIVE VOC DETECTIONS
NAWC WARMINSTER

COMPOUND	HN-85S Shallow			HN-85I Inter		
	6/98 [2]	6/98 [5]	06/00 [3]	6/98 [2]	6/96 [5]	06/00 [3]
CARBON DISULFIDE				2		
1,1-DICHLOROETHENE						
1,1-DICHLOROETHANE						
CIS-1,2-DICHLOROETHENE (or TOTAL)						
CHLOROFORM						
1,1,1-TRICHLOROETHANE						
CARBON TETRACHLORIDE						
TRICHLOROETHENE						
TETRACHLOROETHENE						
TOLUENE						
TRICHLOROFLUOROMETHANE						

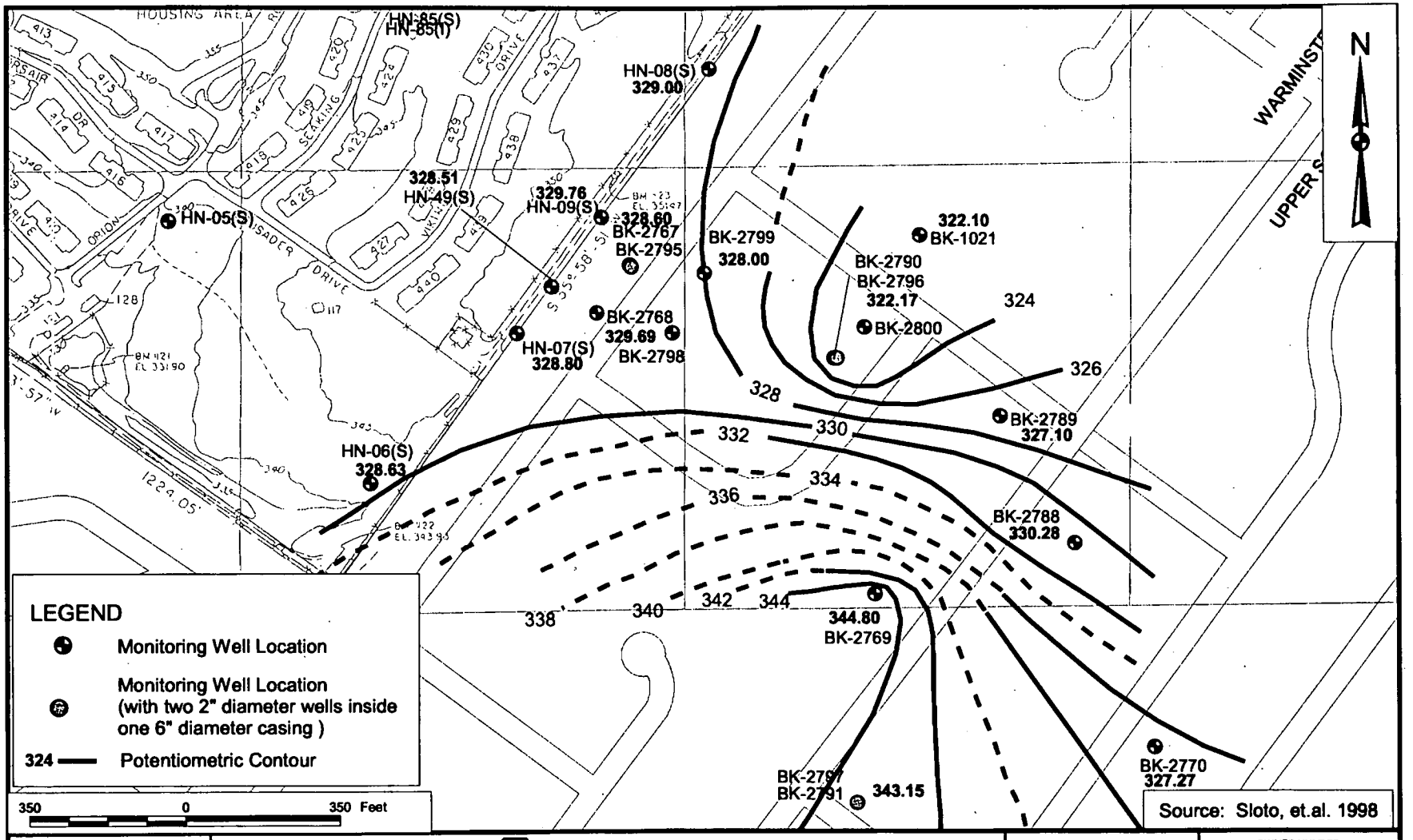
Concentrations reported in ug/l
Blank cell = non detect
J = estimated concentration
(1) Halliburton NUS Area B Hydrogeologic Report, April 1995.
(2) TetraTech NUS Summary Report for Area B Groundwater Monitoring, October 1998.
(3) TetraTech NUS supplemental sampling conducted in June 2000.
(4) Navy Perimeter Monitoring Program 12/94 to ongoing, various Perimeter Monitoring Reports.
(5) Brown & Root Environmental Navy Enlisted Housing Area Well Installation and Sampling, July 1998.

FIGURES



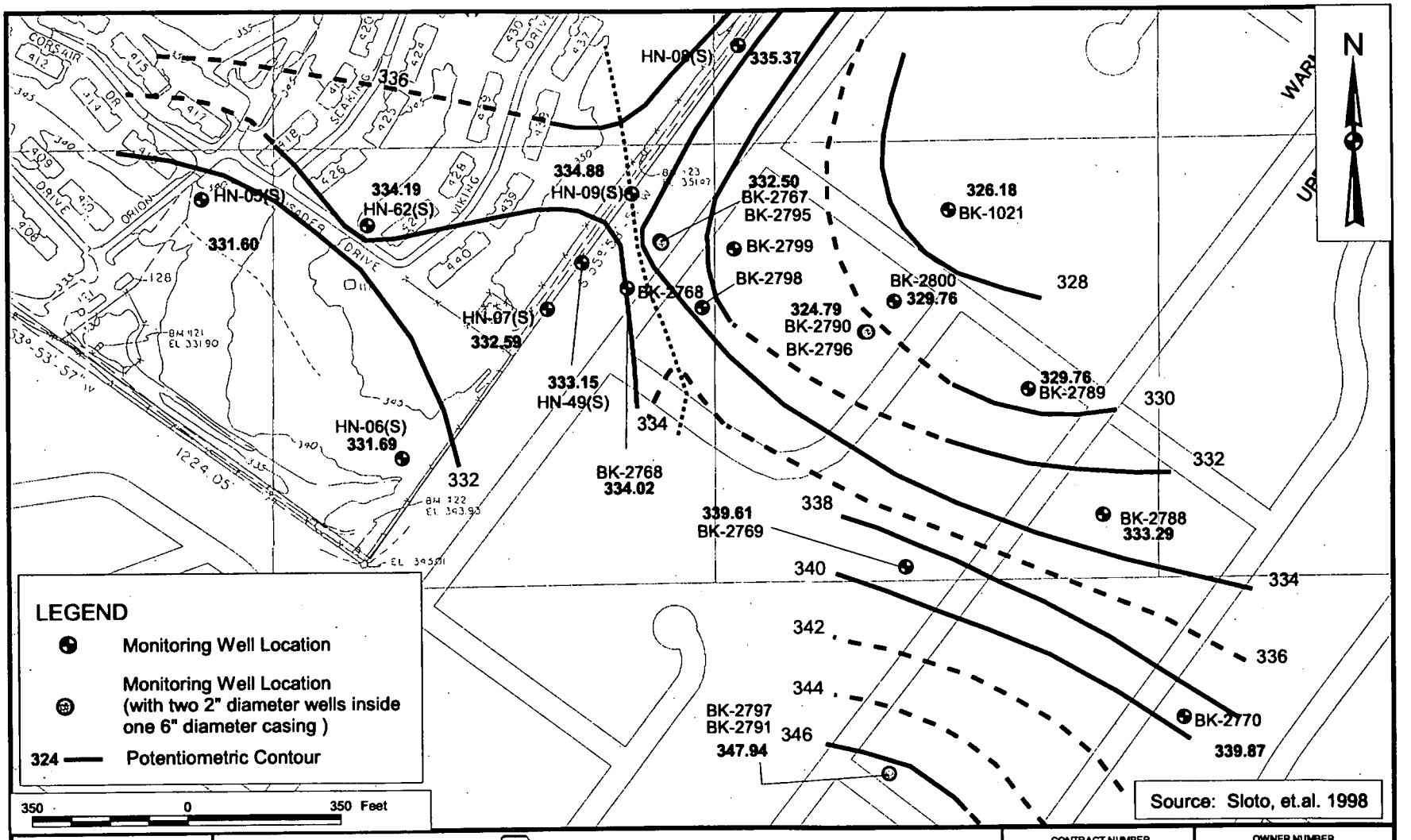
DRAWN BY: J. BELLONE — DATE: 9/6/00	Tetra Tech NUS, Inc.	CONTRACT NUMBER: 7603	OWNER NUMBER: —
CHECKED BY: — — DATE: —	CARBON TETRACHLORIDE DETECTIONS IN GROUNDWATER CASEY VILLAGE AREA NAWC WARMINSTER, PENNSYLVANIA	APPROVED BY: — DATE: —	
COST/SCHEDULE-AREA		APPROVED BY: — DATE: —	
SCALE: AS NOTED		DRAWING NO.: FIGURE 1	REV: 0

P:\GIS\NAWC_WARMINSTER\CASEY_VILLAGE_AREA\APR\CARBON TETRACHOLRIDE IN GROUNDWATER JCB 9/11/00



DRAWN BY: J. BELLONE — DATE: 8/18/00	Tetra Tech NUS, Inc.	CONTRACT NUMBER: 7606	OWNER NUMBER: —
CHECKED BY: — — DATE: —	POTENTIOMETRIC SURFACE IN WELLS SCREENED BETWEEN 18-64 FEET BELOW LAND SURFACE AUGUST 3, 1995 CASEY VILLAGE AREA BUCKS COUNTY, PENNSYLVANIA	APPROVED BY: — DATE: —	
COST/SCHEDULE-AREA		APPROVED BY: — DATE: —	
SCALE: AS NOTED		DRAWING NO.: FIGURE 2	REV: 0

P:\GIS\NAWC_WARMINSTER\CASEY_VILLAGE_AREA\APR\SHALLOW POTENTIOMETRIC - 8/3/1995 JCB 9/11/00



DRAWN BY: J. BELLONE — DATE: 8/16/00	Tetra Tech NUS, Inc.	CONTRACT NUMBER: 7606	OWNER NUMBER: —
CHECKED BY: — — DATE: —	POTENTIOMETRIC SURFACE IN WELLS SCREENED BETWEEN 18-64 FEET BELOW LAND SURFACE FEBRUARY 15, 1996 CASEY VILLAGE AREA BUCKS COUNTY, PENNSYLVANIA	APPROVED BY: — — DATE: —	
COST/SCHEDULE-AREA		APPROVED BY: — — DATE: —	
SCALE: AS NOTED		DRAWING NO.: FIGURE 3	REV: 0

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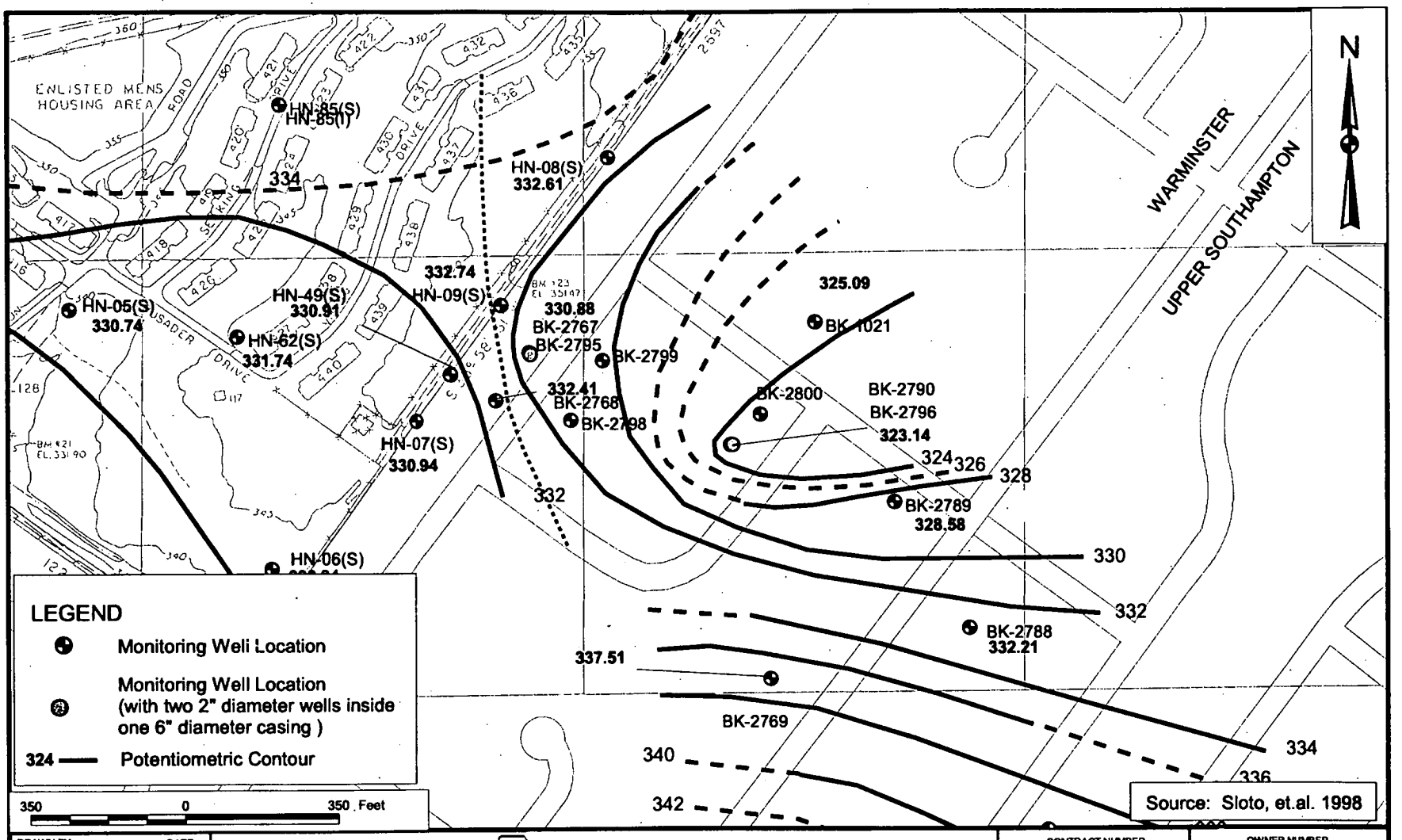

DRAWN BY: J. BELLONE	DATE: 9/16/00	Tetra Tech NUS, Inc.	CONTRACT NUMBER: 7606 / OWNER NUMBER: —
CHECKED BY: —	DATE: —	POTENTIOMETRIC SURFACE IN WELLS SCREENED BETWEEN 18-64 FEET BELOW LAND SURFACE OCTOBER 7, 1996 CASEY VILLAGE AREA BUCKS COUNTY, PENNSYLVANIA	APPROVED BY: — / DATE: —
COST/SCHEDULE-AREA			APPROVED BY: — / DATE: —
SCALE: AS NOTED			DRAWING NO.: FIGURE 4 / REV: 0

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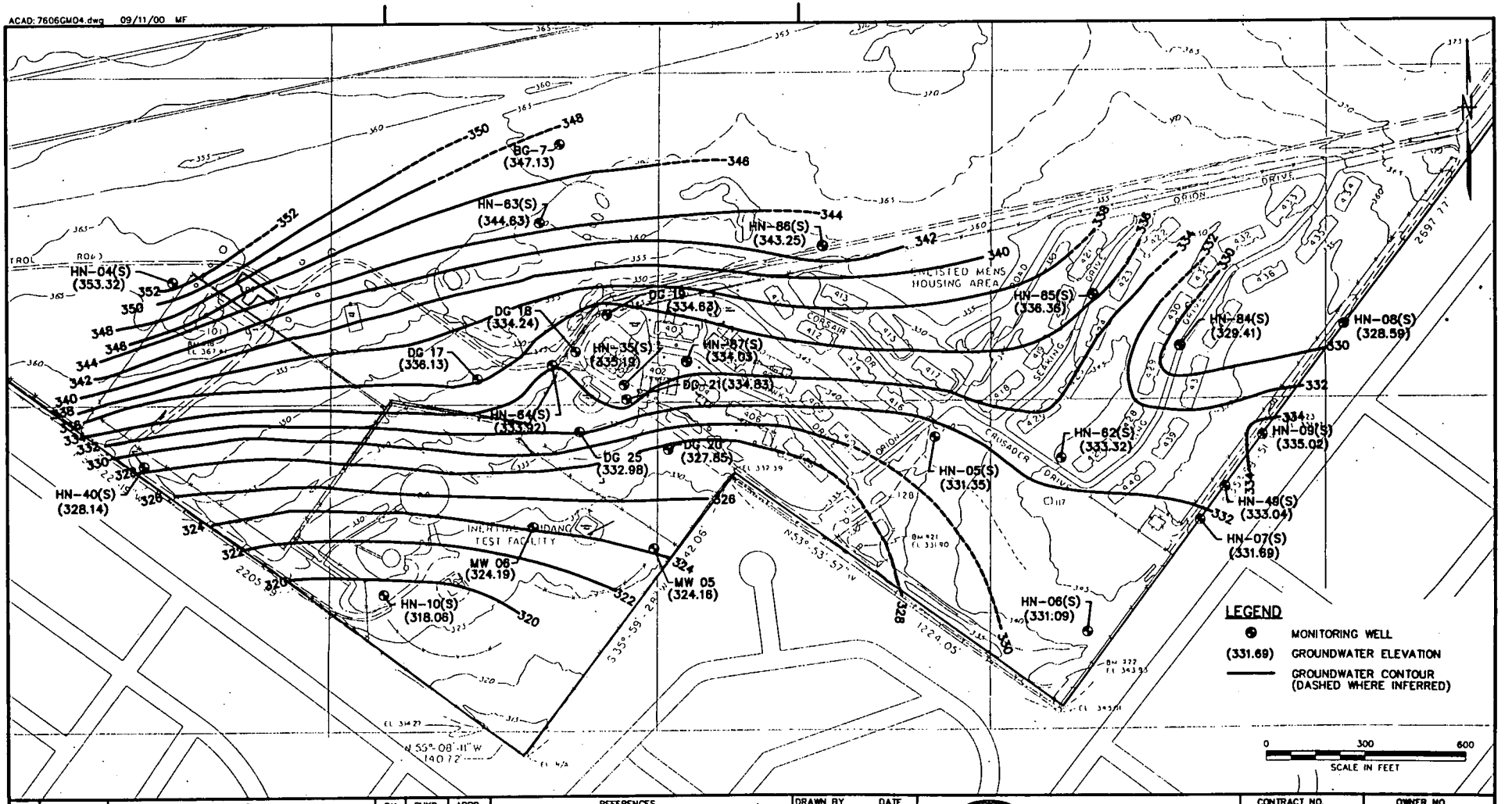


NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

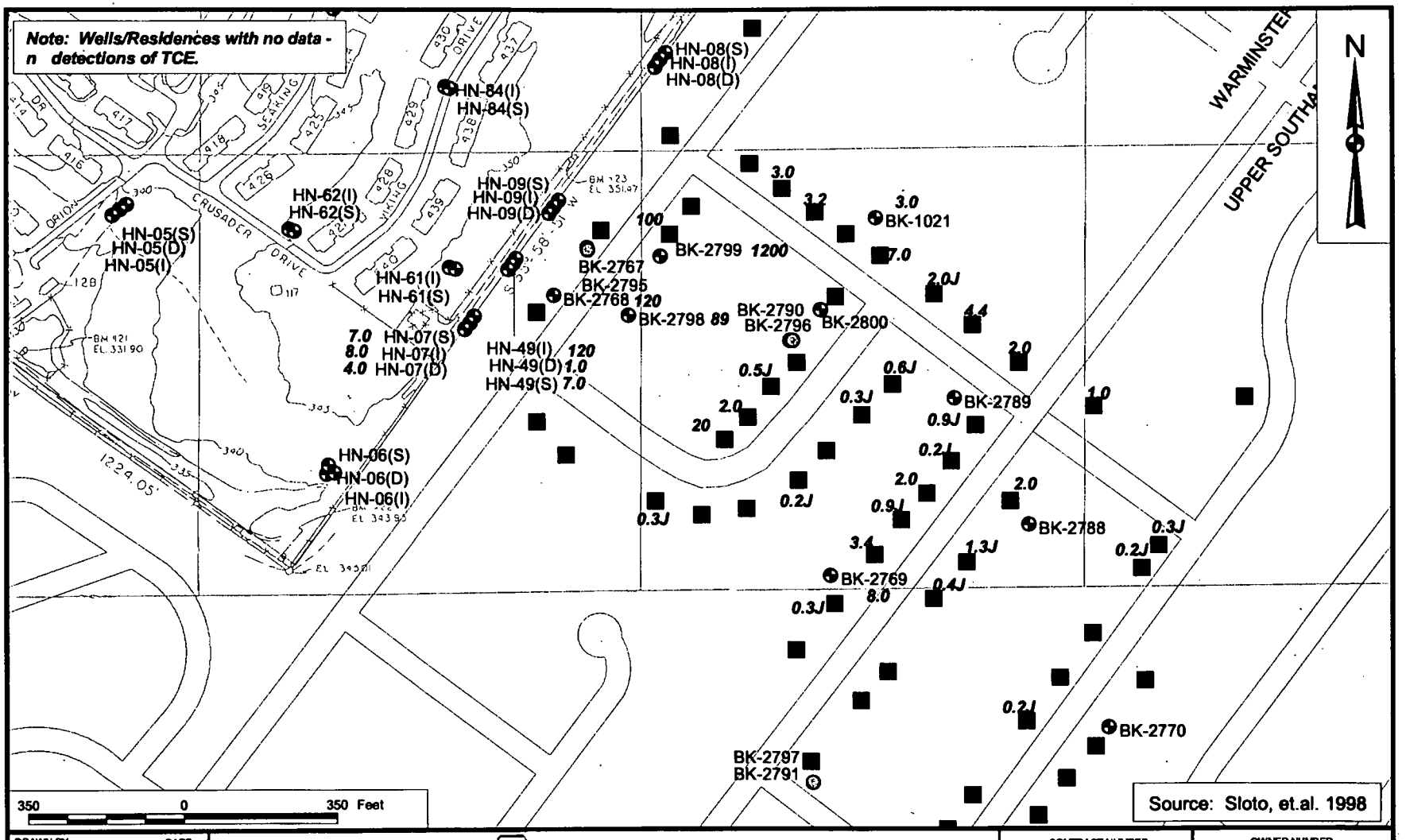
DRAWN BY MF DATE 9/11/00
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

Brown & Root Environmental

SHALLOW GROUNDWATER FLOW DIRECTIONS
(WELL DEPTH RANGE <80 FEET)
JUNE 3, 1998
AREA B, SHENANDOAH WOODS
NAWC WARMINSTER, PA

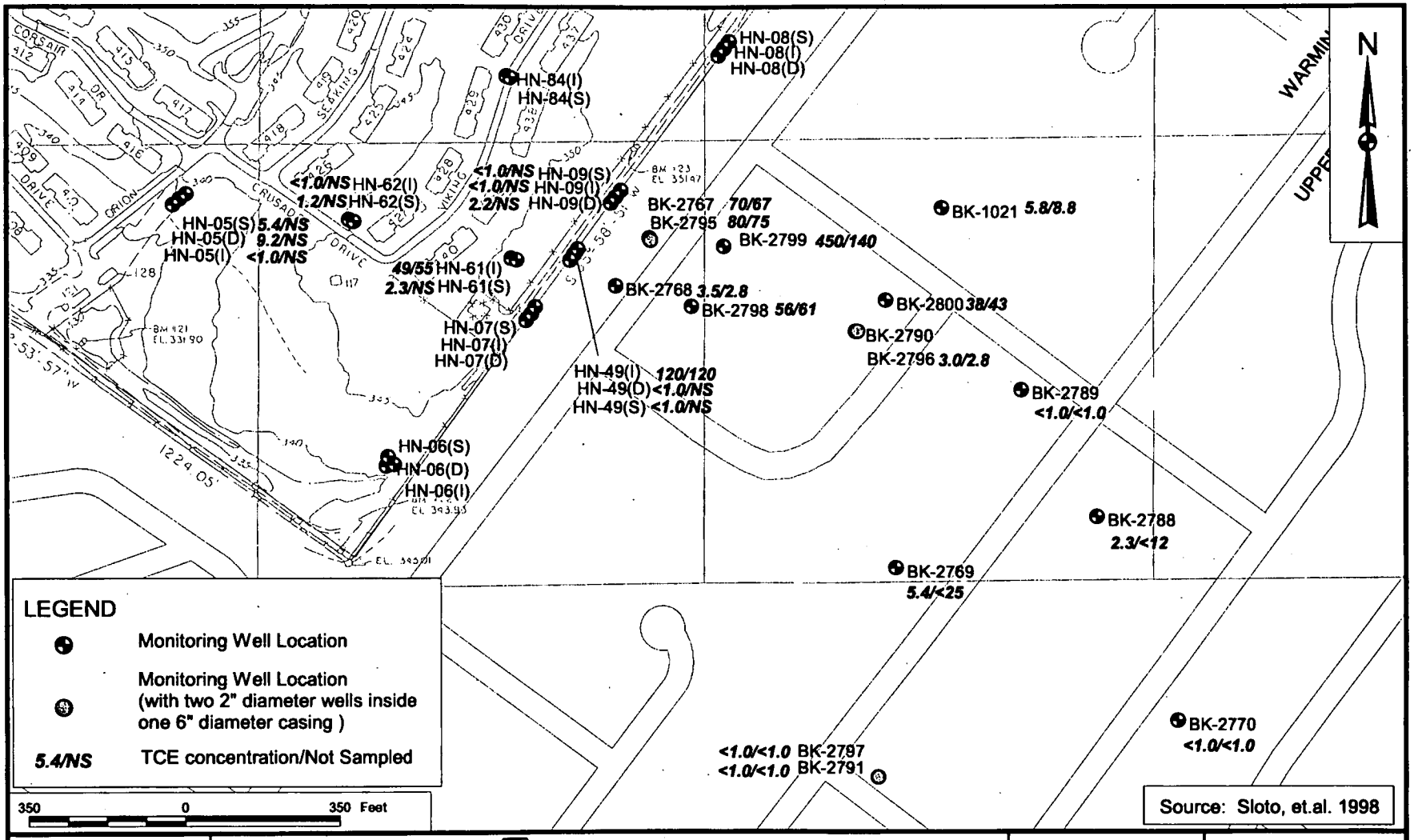
CONTRACT NO. 7606 | OWNER NO. 0291
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 5 | REV. 0

FORM CADD NO. SOUTH_BH.DGN - REV 0 - 02/11/97



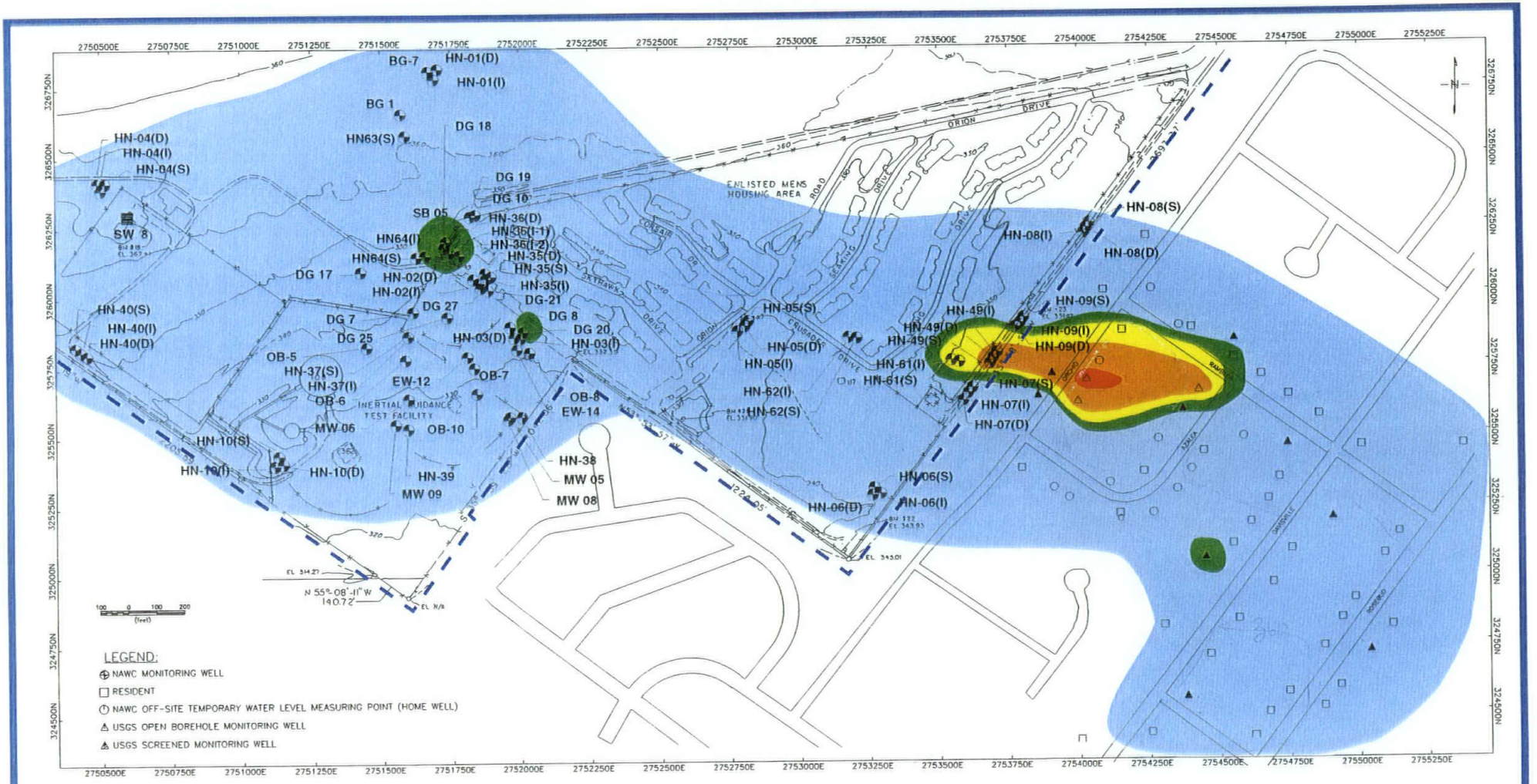
DRAWN BY: J. BELLONE	DATE: 9/6/00	Tetra Tech NUS, Inc.	CONTRACT NUMBER: 7603 / OWNER NUMBER: —
CHECKED BY: —	DATE: —	TCE CONCENTRATIONS (ug/L), 1993-1994 CASEY VILLAGE AREA NAWC WARMINSTER, PENNSYLVANIA	APPROVED BY: — / DATE: —
COST/SCHEDULE-AREA			APPROVED BY: — / DATE: —
SCALE: AS NOTED			DRAWING NO.: FIGURE 6 / REV: 0

P:\GIS\NAWC_WARMINSTER\CASEY_VILLAGE_AREA\APR\TCE CONCENTRATIONS 1993-1994 JCB 9/6/00



DRAWN BY: J. BELLONE	DATE: 9/6/00	Tetra Tech NUS, Inc.	CONTRACT NUMBER: 7603 / OWNER NUMBER: —
CHECKED BY: —	DATE: —	TCE CONCENTRATIONS (ug/L), FEBRUARY-MARCH/OCTOBER 1996 CASEY VILLAGE AREA BUCKS COUNTY, PENNSYLVANIA	APPROVED BY: — / DATE: —
COST/SCHEDULE-AREA			APPROVED BY: — / DATE: —
SCALE: AS NOTED			DRAWING NO.: FIGURE 7 / REV: 0

P:\GIS\NAWC_WARMINSTER\CASEY_VILLAGE_AREA.APR\TCE CONCENTRATIONS 1996 JCB 9/6/00



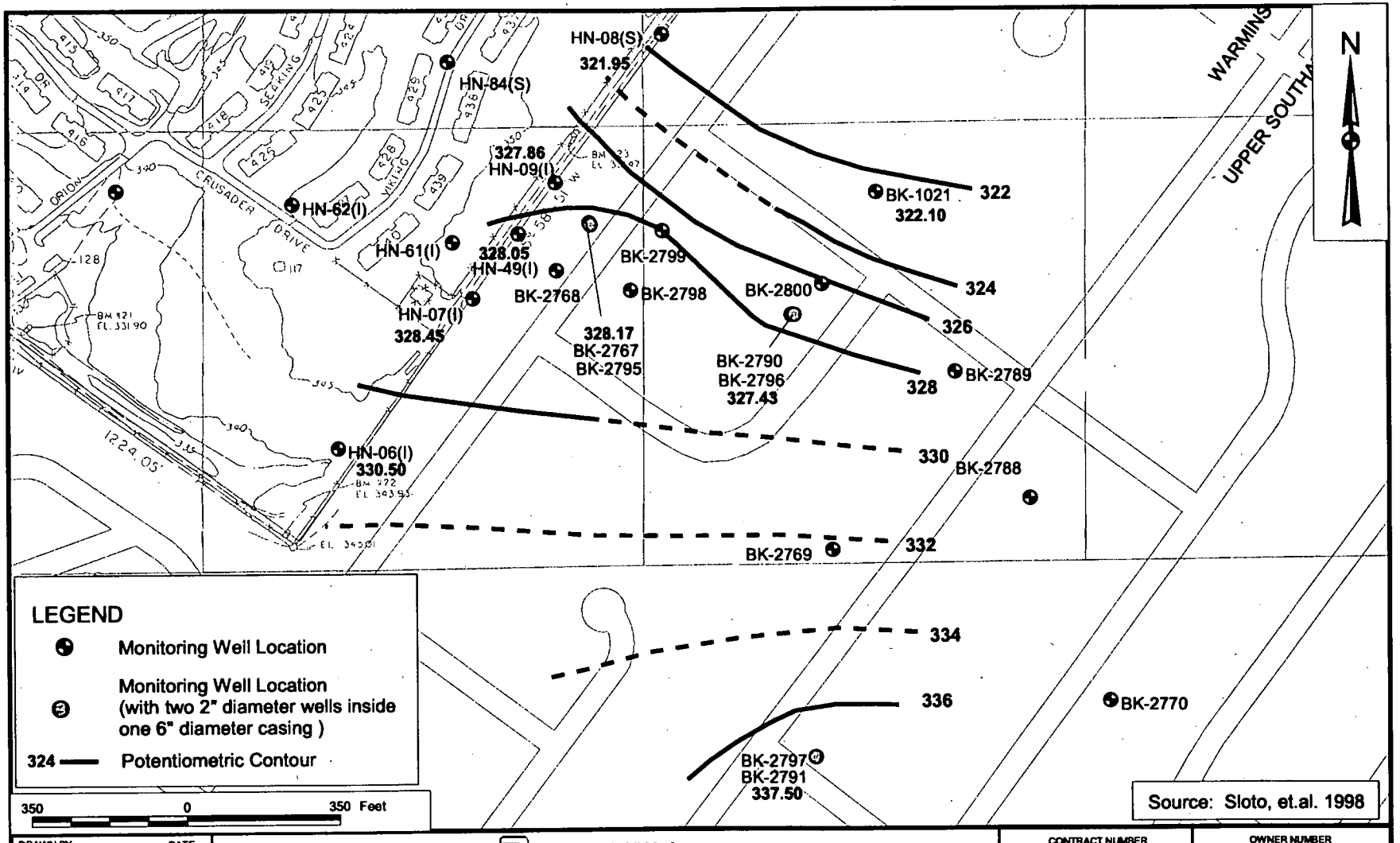
Aqueous TCE Results

Note: Data from 1993-1994 sampling, except for clusters HN49, 61, and 62 (1995-1996 results).

Source:
Administrative Record Document Nos. 53, 92 and 93
USGS and B&RE Sampling Results (1995, 1996)

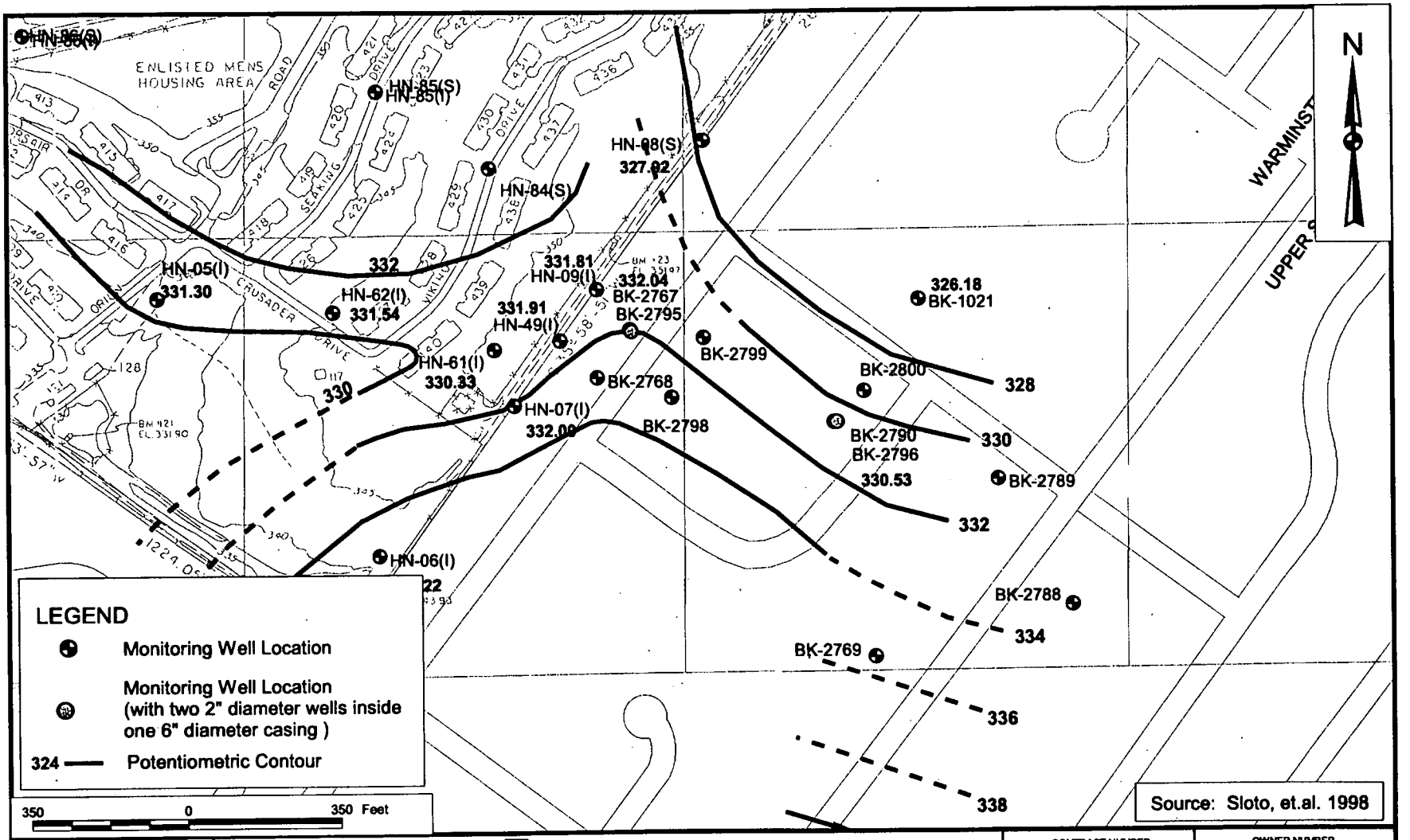
FIGURE 8

NAWC Warminster



DRAWN BY: J. BELLONE; DATE: 8/28/00	Tetra Tech NUS, Inc.	CONTRACT NUMBER: 7606	OWNER NUMBER: —
CHECKED BY: —; DATE: —	POTENTIOMETRIC SURFACE IN WELLS SCREENED BETWEEN 48-106 FEET BELOW LAND SURFACE AUGUST 3, 1995 CASEY VILLAGE AREA BUCKS COUNTY, PENNSYLVANIA	APPROVED BY: —; DATE: —	
COST/SCHEDULE-AREA		APPROVED BY: —; DATE: —	
SCALE: AS NOTED		DRAWING NO.: FIGURE 9	REV: 0

P:\GIS\NAWC_WARMINSTER\CASEY_VILLAGE_AREA.APR\Intermediate_POTENTIOMETRIC - 8/3/1995 JCB 9/11/00



DRAWN BY: J. BELLONE	DATE: 8/28/00	Tetra Tech NUS, Inc.	CONTRACT NUMBER: 7606 / OWNER NUMBER: —
CHECKED BY: —	DATE: —	POTENTIOMETRIC SURFACE IN WELLS SCREENED BETWEEN 48-106 FEET BELOW LAND SURFACE FEBRUARY 15, 1996 CASEY VILLAGE AREA BUCKS COUNTY, PENNSYLVANIA	APPROVED BY: — / DATE: —
COST/SCHEDULE-AREA:			APPROVED BY: — / DATE: —
SCALE: AS NOTED			DRAWING NO.: FIGURE 10 / REV: 0

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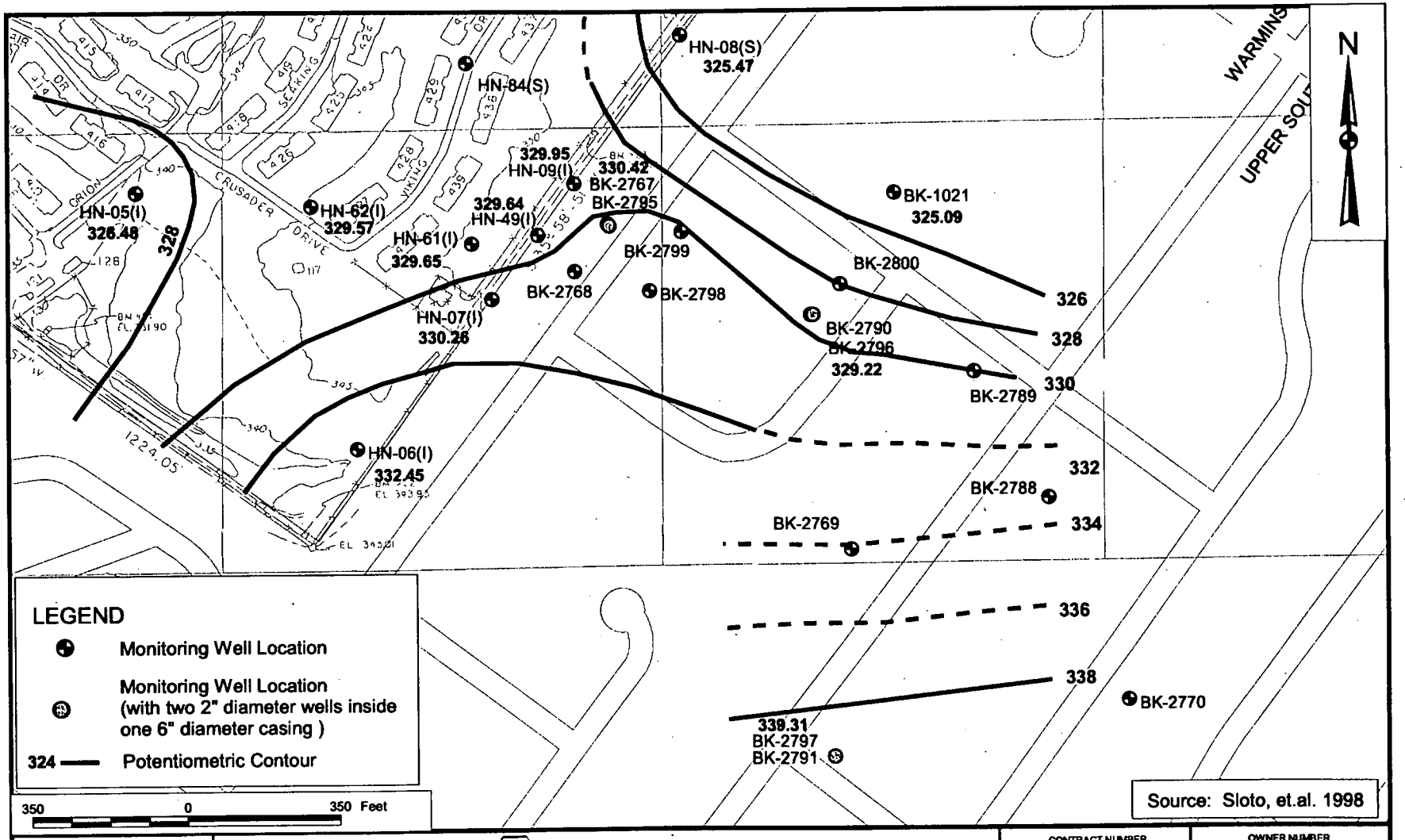

DRAWN BY: J. BELLONE — DATE: 8/28/00	Tetra Tech NUS, Inc.	CONTRACT NUMBER: 7606	OWNER NUMBER: —
CHECKED BY: — — DATE: — —	POTENTIOMETRIC SURFACE IN WELLS SCREENED BETWEEN 48-106 FEET BELOW LAND SURFACE OCTOBER 7, 1996 CASEY VILLAGE AREA BUCKS COUNTY, PENNSYLVANIA	APPROVED BY: — DATE: —	
COST/SCHEDULE-AREA		APPROVED BY: — DATE: —	
SCALE: AS NOTED		DRAWING NO.: FIGURE 11	REV: 0

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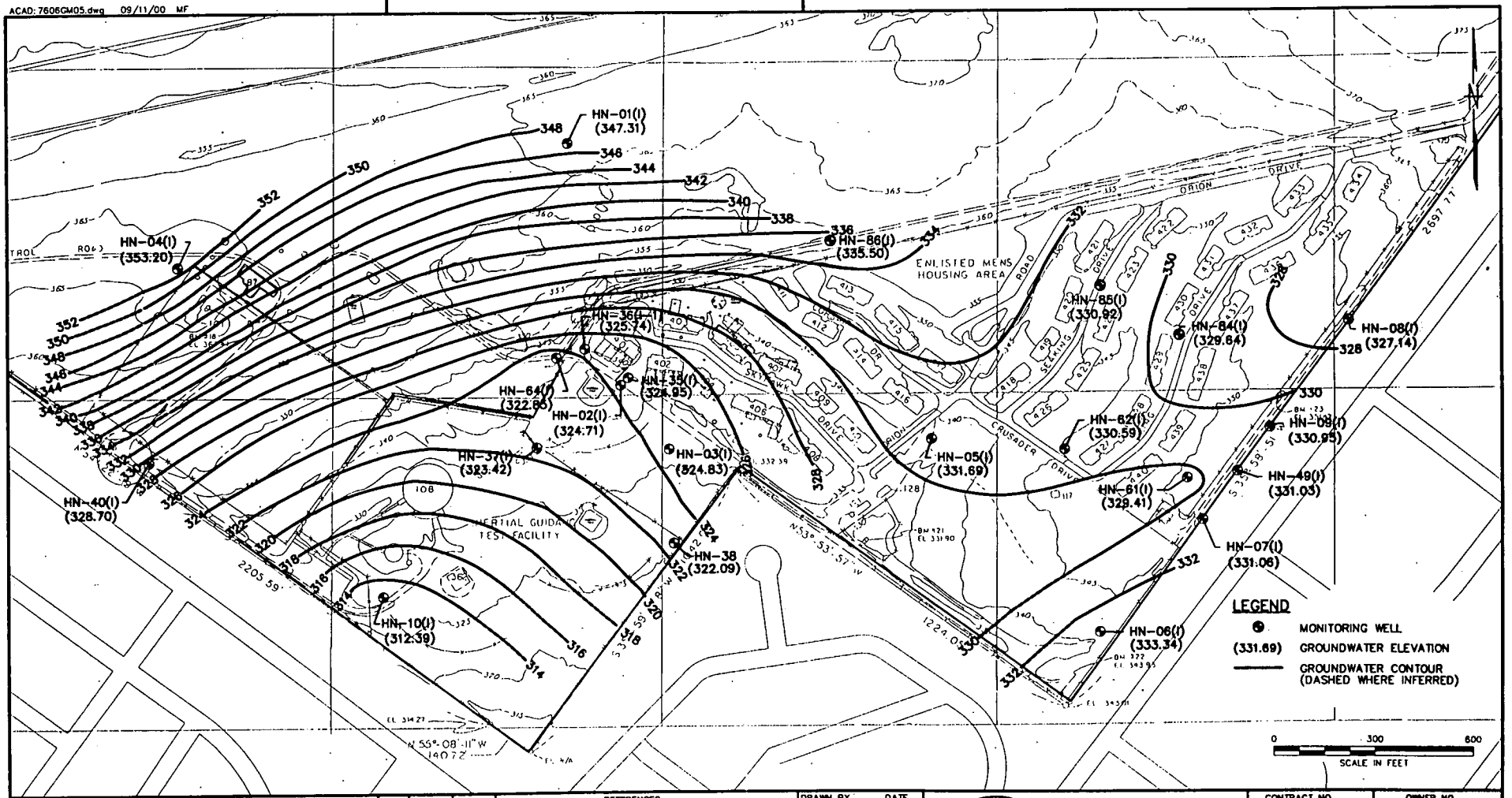

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY MF DATE 9/11/00
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

Brown & Root Environmental

INTERMEDIATE GROUNDWATER FLOW DIRECTIONS
(WELL DEPTH RANGE 60–110 FEET)
JUNE 3, 1998
AREA B, SHENANDOAH WOODS
NAWC WARMINSTER, PA

CONTRACT NO. 7606 | OWNER NO. 0291
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 12 | REV. 0

FORM CADD NO. SOUTH_BM.DGN - REV 0 - 02/11/97

APPENDIX A

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
1650 Arch Street
Philadelphia, Pennsylvania 19103-2029

SUBJECT: Shenandoah Woods Area GW
NAWC - Warminster

9/14/00

FROM: Dawn A. Ioven, Toxicologist DAI
Technical Support Section (3HS41)

TO: Darius Ostrauskas, RPM
Federal Facilities Branch (3HS13)

Ground water data collected from the Shenandoah Woods Area at NAWC - Warminster were reviewed to determine the potential for adverse health effects under a future residential exposure scenario. Specifically, carbon tetrachloride was identified by EPA and the Navy as a chemical of possible concern at the site and is, therefore, the focus of this memo.

Several rounds of ground water sampling (01/94 through 06/00) were evaluated for the presence of carbon tetrachloride. Two monitoring wells in close proximity to each other (HN-09S and HN-62S) were found to consistently contain the highest concentrations of this compound over time. For the purpose of estimating upper bound risks, analytical results from these wells were combined to first predict data distribution (normal versus log normal) and, subsequently, to calculate an exposure point concentration for carbon tetrachloride. (Refer to Table 1.)

For children, ingestion of ground water and dermal contact while bathing were considered to be potentially viable routes of exposure under a future land-use scenario. For adults, exposure via ingestion and inhalation (during showering) was assessed. In this regard, detailed dose equations and exposure input parameters are provided in Tables 2 and 3.

Potential risks – both non-cancer and cancer – to future child and adult residents are also presented in Tables 2 and 3:

- Non-cancer risks are expressed in terms of a Hazard Quotient (HQ). The sum of HQ values from all exposure pathways and routes is referred to as the Hazard Index (HI). *For similar target organs or endpoints of toxicity, an HI value less than one implies that detrimental non-cancer effects are not expected to occur.*

- Carcinogenic risks are described as the probability of developing cancer from exposure to site-related contaminants. EPA typically defines excess cancer risks within the range of 1E-06 to 1E-04 (or less) to be acceptable, with 1E-06 being the point-of-departure. *Action to mitigate exposure is generally taken by EPA when the risk posed by a site surpasses 1E-04, which translates to 1 additional chance in ten thousand of developing cancer.*

Based on conservative assumptions related to exposure, neither future child residents (HI = 0.9) nor future adult residents (HI = 0.4) are expected to experience adverse health impacts due to carbon tetrachloride in ground water at this site. Further, the potential cumulative cancer risk to future residents (2.0E-5) falls within EPA's generally accepted limits, as defined previously in this memo. Consequently, from a human health perspective, there is no need for remedial action or for additional investigation at the site due to the presence of carbon tetrachloride in ground water. (Refer to Table 4 for a summation of risks.)

cc: Kathy Davies, Hydrogeologist (3HS41)

TABLE 1

NAWC - Warminster
Shenandoah Woods Area GW
Carbon Tetrachloride

N = 12

MONITORING WELL (SAMPLING DATE)	CONCENTRATION (ug/L)	DIFF. SQUARES	LN(CONCENTRATION)	DIFF. OF SQUARES
HN-09S (01/94)	8	0.765625	2.07944154167984	0.00674734713875739
HN-09S (04/95)	7	3.515625	1.94591014905531	0.046515114618847
HN-09S (01/96)	9.4	0.275625	2.24070968927596	0.00626090968971892
HN-09S (10/96)	6.5	5.640625	1.87180217690159	0.0839733768681365
HN-09S (06/98)	8	0.765625	2.07944154167984	0.00674734713875739
HN-09S (12/98)	8	0.765625	2.07944154167984	0.00674734713875739
HN-62S (01/96)	11	4.515625	2.39789527279837	0.0558431221392057
HN-62S (10/96)	13	17.015625	2.56494935746154	0.162703789952453
HN-62S (06/98)	9	0.015625	2.19722457733622	0.00127026651177252
HN-62S (12/98)	9	0.015625	2.19722457733622	0.00127026651177252
HN-62S (06/99)	11	4.515625	2.39789527279837	0.0558431221392057
HN-62S (06/00)	6.6	5.175625	1.88706964903238	0.0753580075077499
MEAN:	8.875	42.9825	MEAN: 2.1815887789962	0.509280017355134
	SD:	[illegible]	TRANS. SD:	0.215170126634634
t:	1.771		H:	1.845
	95%UCL:	[illegible]	UCL-LN:	10.0184[illegible]471921
COEFF. OF VAR:		0.222731238318544		0.0995428114944858

TABLE 2

NAWC - Warminster
Shenandoah Woods Area GW
Future Residential Risks -- Child Receptor

ORAL EXPOSURE TO GROUNDWATER

EQUATIONS:

D = C x IR x ED x EF / BW x AT

D = ORAL DOSE (MG/KG/DAY)
C = CONCENTRATION IN WATER (MG/L)
IR = INGESTION RATE (L/DAY)
ED = EXPOSURE DURATION (YRS)
EF = EXPOSURE FREQUENCY (DAYS/YR)
BW = BODY WEIGHT (KG)
AT = AVERAGING TIME (DAYS)

HQ = D / RFD

HQ = HAZARD QUOTIENT
D = NONCARCINOGENIC DOSE (MG/KG/DAY)
RFD = REFERENCE DOSE (MG/KG/DAY)

CR = 1 - EXP(-CSF x D)

CR = CANCER RISK
CSF = CARCINOGENIC SLOPE FACTOR (1/MG/KG/DAY)
D = CARCINOGENIC (TIME-WEIGHTED) DOSE (MG/KG/DAY)

INPUTS

IR	1
EF	350
ED	6
BW	15
AT-NC	2190
AT-C	25550

carbon tetrachloride	0.01	7.0E-004	1.3E-001	0.9	7.1E-006
TOTALS/ORAL DRINK WATER				0.9	7.1E-006

TABLE 2 (continued)

NAWC - Warminster
Shenandoah Woods Area GW
Future Residential Risks – Child Receptor

DERMAL EXPOSURE FROM GROUNDWATER

EQUATIONS:

ORGANICS IF t<t*, then DA = 2 x CF x KP x CV x SQRT (6 x TAU x t / PI)
IF t>t*, then DA = KP x CV x CF x [t/(1+B) + (2 x TAU x ((1+3B)/(1+B)))]

TAU = LAG TIME (HRS)
B = PARTITIONING CONSTANT
t* = TIME (HRS)

DAD = (DA x EF x ED x A) / (BW x AT)

DAD = DERMALLY ABSORBED DOSE (MG/KG/DAY)
A = SKIN SURFACE AREA AVAILABLE FOR CONTACT (CM2)

INPUTS

A	7213
EF	350
ED	6
BW	15
AT-NC	2190
AT-C	25550
t	0.2

carbon tetrachloride	0.01	4.40E-008	2.37E-007	2.2E-002	1.82	6.76E-002	7.59E-001	2.37E-007	4.17E-007	1.0878	1.2028

carbon tetrachloride	4.40E-008	7.0E-004	1.3E-001	0.03	2.3E-007

TOTALS/DERM DRINK WATER	0.03	2.3E-007
TOTAL THIS RECEPTOR	0.9	7.3E-006

TABLE 3

NAWC - Warminster
Shenandoah Woods Area GW
Future Residential Risks – Adult Receptor

ORAL EXPOSURE TO GROUNDWATER

EQUATIONS:

D = C x IR x ED x EF / BW x AT

D = ORAL DOSE (MG/KG/DAY)
C = CONCENTRATION IN WATER (MG/L)
IR = INGESTION RATE (L/DAY)
ED = EXPOSURE DURATION (YRS)
EF = EXPOSURE FREQUENCY (DAYS/YR)
BW = BODY WEIGHT (KG)
AT = AVERAGING TIME (DAYS)

HQ = D / RFD

HQ = HAZARD QUOTIENT
D = NONCARCINOGENIC DOSE (MG/KG/DAY)
RFD = REFERENCE DOSE (MG/KG/DAY)

CR = 1 - EXP(-CSF x D)

CR = CANCER RISK
CSF = CARCINOGENIC SLOPE FACTOR (1/MG/KG/DAY)
D = CARCINOGENIC (TIME-WEIGHTED) DOSE (MG/KG/DAY)

INPUTS

IR	2
EF	350
ED	24
BW	70
AT-NC	8760
AT-C	25550

carbon tetrachloride	0.01	7.0E-004	1.3E-001	0.4	1.2E-005
TOTALS/ORAL DRINK WATER				0.4	1.2E-005

TABLE 3 (continued)

NAWC - Warminster
Shenandoah Woods Area GW
Future Residential Risks – Adult Receptor

INHALATION EXPOSURE

EQUATIONS:

kg = kH x SQRT (MW H / MW)

kg = GAS-FILM MASS TRANSFER COEFFICIENT (CM/HR)
kH = kg FOR WATER (CM/HR: 3000)
MW H = MOLEC. WT. FOR WATER (G/MOL: 18)
MW = MOLECULAR WT. (G/MOL)

kl = kC x SQRT (MW C / MW)

kl = LIQUID-FILM MASS TRANSFER COEFFICIENT (CM/HR)
kC = kl FOR CARBON DIOXIDE (CM/HR: 20)
MW C = MOLEC. WT. FOR CARB. DIOXIDE (G/MOL: 44)

KL = 1 / [(1 / kl) + ((R x T) / (H x kg))]

KL = MASS TRANSFER COEFFICIENT (CM/HR)
R = GAS CONSTANT (ATM M3/MOL K: 8.2E-5)
T = ABSOLUTE TEMP. (K: 293)
H = HENRY'S LAW CONSTANT (ATM M3/MOL)

KaL = KL / SQRT [(T1 x US) / (TS x U1)]

KaL = ADJUSTED OVERALL MASS TRANS. COEFF. (CM/HR)
T1 = CALIB. WATER TEMP OF KL (K)
TS = SHOWER WATER TEMP. (K)
U1 = WATER VISCOSITY AT T1 (CP)
US = WATER VISCOSITY AT TS (CP)

CWD = C x CF x (1 - EXP [(-KaL x ts) / (60 x d)])

CWD = CONC LEAVING SHOWER DROPLET AFTER TIME ts (UG/L)
C = CONCENTRATION IN WATER (MG/L)
CF = CONVERSION FACTOR (UG/MG: 1E3)
ts = SHOWER DROPLET TIME (SEC)
d = SHOWER DROPLET DIAMETER (MM)

S = CWD x FR / SV

S = INDOOR VOC GENERATION RATE (UG/M3/MIN)
FR = SHOWER FLOW RATE (L/MIN)
SV = SHOWER ROOM AIR VOLUME (M3)

D = [(VR x S) / (BW x Ra x 1E6)] x Q

D = INHALATION DOSE (MG/KG/SHOWER)
VR = VENTILATION RATE (L/MIN)
BW = BODY WEIGHT (KG)
Dt = TOTAL DURATION IN SHOWER ROOM (MIN)
Ra = RATE OF AIR EXCHANGE (1/MIN)

Q = Ds + [(EXP(-Ra x Dt)) / Ra] - [(EXP(Ra x (Ds-Dt))) / Ra]

Ds = DURATION OF SHOWER (MIN)

INPUTS:

T1	293	VR	0.83
TS	318	BW	70
U1	1.002	EF	350
US	0.596	ED	24
d	1	AT-NC	8760
ts	2	AT-C	25550
FR	10		
SV	6		
Ds	12	Q	2.4819173
Dt	20		
Ra	0.01667		

carbon tetrachloride	0.01	153.84	2.3E-002	1025.1784	10.696007	10.580803	14.282529	3.7899593	6.3165988	0.0000112

carbon tetrachloride	1.12E-005	5.71E-004	5.3E-002	0.02	1.9E-007
TOTALS/INHAL				0.02	1.9E-007
TOTAL THIS RECEPTOR				0.4	1.7E-005

TABLE 4

NAWC - Warminster
Shenandoah Woods Area GW
Cumulative Future Residential Risk Estimates
Carbon Tetrachloride

Potential Non-Cancer Risks

ingestion	0.9	0.4
dermal	0.03	na
inhalation	na	0.02
Total HI	**0.9**	**0.4**

Potential Cancer Risks

ingestion	1.9E-005
d rmal	2.3E-007
inhalation	1.9E-007
T tal Cancer Risk	**2.0E-006**